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ESSAYS

MEDICAL

AND

PHILOSOPHICAL

BY

GEORGE MARTINE, M. D.

Non fingendum aut excogitandum, sed inveniendum quid Natura faciat aut ferat.

Bacon.

LONDON:

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PREFACE.

IT is now above a Century ſince the illuſtrious and immortal *Harvey* taught the world the Circulation of the Blood; and inſpired into it a more than ordinary keenneſs for Anatomical enquiries. And about the ſame time men began to get a taſte for Experimental and Mechanical Philoſophy. Great things were expected from ſuch a concourſe of circumſtances, ſeemingly favoring very much the improvement of the knowledge of Medicine. But what a diſappointment did the world meet with? Things fell out quite contrary to expectation. Since theſe lights there have perhaps been more abſurdities given out and defended concerning the natural and morbid ſtate of the Human Body, than had been from the beginning of the world to that time. The remaining Galeniſts, the

Chemiſts, the Hypothetical Philoſophers, and even the Mathematicians all contributed towards the ſpoiling of Phyſic; though we muſt in gratitude acknowledge, that in ſome things it was the better for them. Men are naturally exceeding fond of knowledge; eſpecially in thoſe things they think it much concerns them to underſtand: and ſo impatient, that they often embrace a ſhadow for the ſubſtance; flattering themſelves that they know what indeed they are almoſt intirely ignorant of. Had it not been for ſomething of this kind, how could moſt of the Phyſicians of the laſt age have left the old beaten track of obſerving carefully the phænomena of diſeaſes; by which they might be enabled to diſtinguiſh them from one another, and duly to apply the proper remedies tranſmitted to them by their predeceſſors, or found out by their own induſtry? Inſtead of which, neglecting the hiſtory

ſtory of diſeaſes and cures excellently deſcribed by the old writers in Phyſic, they took indeed a ſhorter and leſs laborious way; herein it will be alledged conſulting more their own eaſe, than the relief and ſafety of the ſick committed to their care. A ſuperficial view of what they called the Animal Oeconomy, and a few hypotheſes and plauſible theories of diſeaſes make a much ſhorter courſe of ſtudy; and ſet out one in the world much ſooner and eaſier than a diligent and painful ſurvey of all the material appearances and circumſtances of diſtempers. It were indeed a fine thing if we knew enough of the Human Body, and of the nature of aliments and medicines applied to it, to be able to cure diſeaſes *ſcientifically*, or from a philoſophical knowledge of things. But alas, this is by no means the caſe. Within theſe laſt hundred years bypaſt there have been truly a great many

many improvements in theſe things: and may we go on advancing in ſuch knowledge. But ſtill, beſide other wants, we know ſo little of the nature of the fluids, and of their ſpontaneous and morbid changes, of the fabric, connections and dependencies of the nerves, of the nature and variety of infections, of the manner of the action of medicines on animal bodies, &c. that our chief work in the Practice of Phyſic muſt be that of reaſonable and attentive Natural Hiſtorians; in the mean time nobly aiming at the true Philoſophy of Nature, as far as our limited faculties will allow us. We muſt be thoroughly acquainted with the hiſtory of the phænomena and cures of Diſeaſes: we ſhould know the fabric of the animal machine, and the powers and the laws of the actions of bodies on one another; dropping all precarious theories and ill-grounded ſpeculations, which flatter us with the

ſhew

ſhew of their help, but like *Ignes fatui* deceive us and lead us aſtray, if we truſt to them. Nor let us amuſe ourſelves with the thoughts of a complete Philoſophical Phyſic, until we have *data* enough to raiſe it up in the Lord *Verulam*'s way upon the ſolid plan of obſervations and experiments, and the true laws of Nature. And only in as far as we can deduce things according to his rules with certainty and evidence ſhould we pretend to act upon ſpeculative principles, drawn originally from facts and experience.

The whole life and practice of any one man is ſo ſhort and limited, as without the aſſiſtance of the paſt and contemporary obſervations of others to be of very little ſervice to himſelf, and ſtill much leſs to the reſt of mankind. So that we are to neglect no aſſiſtance we can any way come at in forming a right judgment of

diſeaſes. I have in the firſt Eſſay attempted to put together an account of the *Criſes* and *Periods* of Diſeaſes collected from thoſe, in whom we ſhould moſt reaſonably expect to find them; thoſe I mean who took the trouble to obſerve and deſcribe Diſeaſes juſt as Nature ſhewed them: Not from thoſe who drew up ſchemes of the maladies of the Human Body from fancy and ſpeculation; and who, imagining ſuch periods to be inconſiſtent with their views of the Animal Machine, would not allow themſelves to ſee them except in Agues, the Small Pox, and ſome few others, wherein the bent is ſo ſtrong, that the Phyſician is ſcarcely able by all his efforts to alter the regular courſe and tendency of Nature. And as the Natural Hiſtory of Diſeaſes, like that of other things, muſt ever precede the Natural Philoſophy of them; ſuch views of the Hiſtory of the Criſes and Periods of Diſeaſes muſt

muſt always be taken before we attempt to explain the nature and cauſes of theſe appearances.

The operation of Cathartic Medicines treated of in the ſecond Eſſay is another article wherein we very much deceive ourſelves from a pride of mind, and a miſtaken conceit of our own faculties. How little do we really know of the action of other bodies on ours? And yet how readily do we at the very firſt pronounce all purges to act indiſcriminately, differing only in their various ſtimulating forces? Though if we will lay aſide hypotheſes, and conſult mere facts and experience, we ſhall find things quite otherwiſe; and that almoſt all medicines have ſome peculiar or ſpecific powers or virtues diſtinguiſhing them from the reſt of the claſs under which they are ranged. As is evident from the common Practice of Phyſic, how-

ever inconſiſtent with the ordinary modern theories.

The reſt of theſe papers were moſt of them read at ſome meetings of the Royal Society laſt winter. They are all in the way of the Hiſtory and Philoſophy of Nature: and chiefly concerning the meaſure of the degrees of Heat; a ſubject hitherto but very indiſtinctly handled; and yet without a knowledge of which our ideas of Heat, and of its effects on bodies muſt be very imperfect. They may be the occaſion of making farther advances in the Philoſophy of this part of Nature, as we, or others better qualified may have opportunities of making more obſervations on this almoſt inexhauſtible ſubject.

THE

THE

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AN

AN ESSAY ON THE PERIODS and CRISES OF DISEASES.

ESSAY I.

THE first men were either made or born healthy, firm and vigorous. They passed their time in labour and exercise; and fed upon those things their Maker appointed them. No wonder then they lived to a green old age, almost inconceivable to us; and propagated children, enjoying the good constitution of their fathers, and living centuries of years without pain, without disease.

But all this came to an end. The earth itself, whereon men live, and from whence they have all their subsistence, suffered a very great catastrophe. The elements grew less favorable. And by degrees men grew lazy and luxurious. Their lives became short, and these subject to diseases. Few and evil are their days.

ESSAY I.

Such indeed is the ſituation of fallen man that diſeaſes are unavoidable. But in the firſt ages, when men lived in an active, ſober and ſimple manner, they were much rarer, and leſs ſevere, than in the later and more corrupt times. So that, though in all ages of the world all nations have been ſubjected to ſuch infirmities, yet theſe were leſs ſtudied, and fewer remedies diſcovered, than what a greater number, and a greater ſeverity of diſeaſes afterwards rendered neceſſary, and ſubſequent induſtry found out.

2. At firſt external and accidental diſeaſes (as men were always liable to hurts, wounds, bruiſes &c.) were moſt frequent and chiefly conſidered. Internal and ſpontaneous ones were ſcarcer, and commonly looked upon as judgments from the hands of the Almighty; to whom alone application was made for help and deliverance.

Miſſum ad ſua corpora morbum
Infeſto credunt a numine: ſaxa Deorum
Hæc & tela putant *.

So then people thinking theſe diſeaſes to be ſomething ſupernatural, and above human

* Juven. Sat. XIII, 231. Celſ. Medic. Præf. p. 2.

aid,

aid, it is no wonder that neither their nature, nor hiſtory, nor artful cure were at firſt ſo much minded and improved, as were thoſe of a chirurgical nature. Diſeaſes indeed got names from ſome of their moſt obvious ſymptoms; and ſome few remedies were found out, the memory of which was carefully preſerved, and applied in ſimilar caſes, with the beſt judgment and diſcretion rude men were then capable of. But we may juſtly preſume, that in primitive times people's health and recovery from diſeaſes were more owing to their ſound conſtitutions, and ſober lives, than to the number or virtue of their medical helps.

3. In ſome places of the world there were particular perſons and ſocieties ſet apart for the management of diſeaſes. But though they collected remedies and receipts we do not find that in old times they carried their knowledge or hiſtory of internal and ſpontaneous maladies to any height. Even in *Greece* itſelf, where at length that part of medicine came to be better cultivated than any where elſe, for a long time it continued in a rude and very imperfect ſtate. In the time of the *Trojan* war they knew the management of

ESSAY I.

ulcers and wounds, which *Apollo*, *Chiron* and *Esculapius* had introduced, or, at leaſt, greatly improved in the preceding age. And from *Egypt* they had got the knowlege of ſome medicinal ſimples. But the peſtilence and other ſuch diſtempers, as coming from the Gods, they did not attempt to cure; nor, as far as we know, ſo much as to deſcribe. [a] *Esculapius* himſelf ſeems to have died of a violent *Pleuropneumony*. But in thoſe days ſo ignorant were they of that diſeaſe, that from the lividneſs it left on his ſide the opinion generally prevailed, that he was ſtruck dead by a thunderbolt from *Jupiter* [b]: for thoſe who died in this manner were ſaid to be βληθοι in ancient times [c], before the connexion of the parts of the body, and the ſeats of diſeaſes were underſtood.

4. In after ages the deſcendants and ſucceſſors of *Esculapius* extended their views and practice, not confining themſelves to the obſervations and cures of a chirurgical kind. They diſperſed themſelves thro' *Greece*, and ſome of the neighbouring countries, and were

[a] Suid. in Ασκληπιαδαι.

[b] Vid. Pindar. Pyth. 3. Plat. de Repub. 3. Virgil. Aen. VII, 773.

[c] Hippocr. Coac. III, 183. De Vict. Acut. VIII, 1.

erected

erected into ſeveral ſchools for taking care of the ſick, and the improvement of Phyſic. There they kept regiſters of diſeaſes, of their antecedent cauſes, of their ſymptoms, of their periods and conſequences, and of what had been found either hurtful or advantageous in the courſe of them. Then it became a regular art, and the profeſſors thereof began to reduce it to form. They collated their obſervations together; made up deſcriptions of diſeaſes; and from various and innumerable experiments determined thoſe things and methods, which had been found moſt ſucceſful in practice.

5. Many had been the attempts of this kind, and ſome of them not with contemptible ſucceſs for that time. But at length aroſe the great *Hippocrates*, who furniſhed with all the aſſiſtance that could be had from his predeceſſors, and being himſelf a man of great natural parts, of inimitable ſagacity in obſerving the courſe of nature both in a healthy and a morbid ſtate, and of unparalleled application in ſtudying and comparing his own with the obſervations of the ancients, ſet about the deſcription of diſeaſes with ſuch ſucceſs, that in this reſpect few

ESSAY I.

that came after him have deſerved to be compared with him. That excellent rule, [a] Μηδεν εικη, μηδεν ὑστεροξαν, he ſeems to have had deeply imprinted in his mind. How careful was he in obſerving all the external circumſtances which could any way affect thoſe who were committed to his care? The climate of the country, the ſituation of the towns, the ſeaſon of the year, the courſe of the winds, the various changes of the weather; nothing of this kind could eſcape him. He found out what diſeaſes were occaſioned, and how they were to be influenced by any of theſe things. He conſidered what ſhare the difference of age, ſex, conſtitution, ſhape, complexion, paſſions, manner of life, diet &c. had in producing ſuch and ſuch maladies. He has accurately deſcribed how they began, continued and ended, and all their ſeveral ſymptoms and periods; and conſequently has given us a method of propheſying the moſt probable events, when like caſes ſhall fall in our way. This was his maſterpiece. And as the art of *Prognoſticks* is a very uſeful, and certainly the moſt ſurpriſing part of the practice of Phyſic, and whereat the vulgar muſt ſtand a-

[a] VI. Epid. II, 46.

mazed,

mazed, it has gained him the univerſal applauſe of ſucceeding ages: wherein, when polytheiſm was in vogue, they were ready to take him for a God.

6. From innumerable obſervations he arrived at length at ſuch a perfect knowledge of the courſe of diſeaſes, as to be able, by a careful notice of the various circumſtances of them, to foretel the very days of their great changes. In the hiſtories of fevers and feveriſh diſorders handed down to him by his prdeceſſors in the *Coan* School, and likewiſe in thoſe, whereof he himſelf kept a regiſter, he found ſuch and ſuch of them regularly to exhibit certain particular phænomena, depending one upon another, preciſely upon certain particular days: and that conſequently a phyſician was always to have ſuch things in view in the management of his patients.

7. *Hippocrates*'s doctrine of the *criſes* of fevers as contained in his works, and explained by thoſe, who have been at moſt pains to underſtand him, may, I think, be reduced to theſe following articles.

ESSAY I.

I. *Diſeaſes* are various modifications of the body eſſentially diſtinguiſhed one from another. Yea thoſe of a given claſs and denomination, eſpecially *fevers* have their various (κατασασιες) *conſtitutions*; ſo as that in different years and ſeaſons they diſcover a ſpecific difference among themſelves by their various concomitant ſymptoms, and times of duration, and methods of ending, and ſucceeding events.

II. By ſome *vitium* in the blood a *fever* is produced: wherein nature is conſtantly at work to bring the *peccant matter* to ſuch a ſtate as that it may be expelled out of the body by ſome evacuation.

III. Sometimes indeed the ſtrength and conſtitution of the patient is ſo good, or the *peccant matter* is of ſo little force, that it is gradually overcome, and (κατα βραχυ) *inſenſibly* expelled out of the body *paulatina ſolutione*. But for the moſt part this *peccant matter* is ſo groſs, and of ſuch quantity, that in its expulſion from the maſs of blood it ſhews itſelf by a plentiful and very ſenſible *evacuation*.

IV. This is ſometimes, eſpecially in the warmer climes and ſeaſons, and in thoſe of a hot temperament, and full ſanguineous habit of body, a large *hæmorrhage* by the burſting or opening of ſome conſiderable bloodveſſels, as of the *noſe*, or *anus*, or *uterus*; but moſt commonly is a plentiful *excretion* by ſome of the great *emunctories*, as by *ſweat*, *urine*, *ſalivation*, *vomit*, or *ſtool*. And it may happen too that nature may not be able to digeſt the *morbid matter* ſufficiently to have it freely expelled out of the body: ſo that it is ſtill retained there, and by an ἀποστασις thrown only out of the maſs of blood, and common courſe of circulation upon ſome particular part: ſo as to end at length either in a good or ill way, according to the fabric, uſe and importance, and other circumſtances of the part ſo affected, and the ſtrength and ſoundneſs of the patient.

V. In the beginning and increaſe of the *fever* the *morbid matter* is very intimately mixed with the maſs of blood; and then the diſeaſe is ſaid to be in a *crude ſtate*. Afterwards ſucceeds the *concoction*, when it is gradually, in certain determined ſpaces of time, prepared, digeſted, and rendered fit to undergo

ESSAY I. undergo a separation from the rest of the mass, and expelled out of the body. Which separation and expulsion is the true *critical evacuation*.

VI. Sometimes the *peccant matter* is so malignant, or the patient so unsound, or his management so irregular, that he suffers a great many disorderly paroxysms, and partial evacuations: and at length either dies, or with difficulty wears out of the disease πανυ ατακτως, και πεπλανημενως, και ακριτως. But ordinarily the disease goes regularly on, the signs of a beginning *concoction* appear, and, when it is accomplished, follows the *perturbatio critica*, an increase of some violent symptoms, and a struggle, as it were, between the force of nature, and the force of the disease just before the *critical evacuation*. Which is performed suddenly, so as, when attended with bad and unfavourable symptoms, to kill the patient; or on the other hand, when the *vis vitæ* gets the better of the disease, to leave him in a tolerably easy state; and that he is *judged* to be delivered from his *fever* by this salutary *crisis*. Whereas if this be imperfect, he is either not intirely free from the *fever*, or he continues in danger of a *relapse*.

VII.

VII. The *Criſes* of *fevers* may happen on any *day* of the diſeaſe. But by experience and careful obſervation it was found out, that they oftener appear on ſome particular *days*, and with a better effect than on ſome others, on which they either happen ſeldom, or ſeldom prove beneficial; as leaving the patient either dead, or but half-well, or obnoxious to a relapſe. Thus according to *Galen*, who was at a great deal of pains to collect all the *Hippocratical* doctrines and obſervations, and who in this affair is but tranſcribed by the writers that came after him; thus, I ſay, as *Galen* has obſerved, a much greater number of fevers terminate favourably on the 7 day than on any other; very many too on the 14: and then ſucceed in order the 9, 11, 20 (or 21) 17, 5, 4, 3, 18, 27 (28) 40, 34, 24, 31, 37. Not but that ſudden *criſes* may ſometimes fall on other *days*, ſuch as is eſpecially the 6. But then this ſeldom happens in a deſirable way, as coming on in a troubleſom, obſcure or imperfect manner; either killing the patient, or at leaſt leaving for the moſt part ſome noxious remains of the diſeaſe, or diſpoſing the body to ſome other malady.

ESSAY I.

malady. Akin to the 6, tho' perhaps not ſo unlucky, are the 8, 10, 12, 16, 19. The 13 is not reckoned ſo lucky as thoſe of the former claſs, nor ſo bad as the others, but in a middle, as it were, between them. And to the former claſs of lucky *days Diocles* added too the 1 and 2; and he and *Archigenes* preferred the 18 to the 17, and conſequently the 21 to the 20, the 25 to 24, the 28 to 27 *&c.*

VIII. In *fevers* which are terminated within 14 *days* the ſymptoms are violent. They are even pretty ſtrong tho' they reach to 20. From thence to the *fevers* of 40 days the ſymptoms loſe their force and ſignificancy. So that the very ſlow ones languiſh much, for the moſt part either ending *inſenſibly*, or in *abſceſſes*, ſeldom in *ſenſible evacuations*. The moſt noted days after that period are the 60, 80, 100, 120; near to which, though perhaps not preciſely on them, the diſeaſe takes an extraordinary turn.

IX. The laudable moſt ordinary *critical days* may frequently be foretold beforehand by an expert and accurate obſerver of the diſeaſe from ſeveral circumſtances of it; but eſpe-

eſpecially from the appearance of the *ſigns* of a right *concoction*: which *ſigns* generally begin to ſhew themſelves about 3 days before the expected *criſis*. Thus on the 4 *day* of the *fever*, from certain circumſtances then appearing we perceive if we may reaſonably hope for a *criſis* on the 7. For which reaſon the 4 is called the *indicatory day* of the 7; as by the ſame rule the 11 is the *index* of the 14, the 17 of the 20, and ſo on of the reſt. ESSAY I.

8. This is the *Hippocratical* ſcheme of the *periods* and *criſes* of fevers, as he collected it from nature itſelf. It was not a theory drawn from the *Pythagorean* doctrine of numbers as *Celſus* would make us believe[a], and many learned men have taken for granted upon his authority. No: the abſtracted ſpeculations of this philoſopher were better received in the weſt; they had no great credit in thoſe places where *Hippocrates* lived. Here the *Ionic* doctrines of *Thales*, *Anaxagoras*, *Leucippus*, *Democritus*, &c. prevailed; the corporeal philoſophy was in vogue, and every thing was explained by matter and motion. So that the conceptions

[a] Medic. III, 5. p. 122.

of

ESSAY I. of these men were too gross; with them there was no room for the airy notions of *Pythagoras*, which were received only in the *Italick* schools. The 4th book περὶ νουσων, tho' it be not allowed to have been written by *Hippocrates* himself, was probably compiled by some of his disciples or successors, and adjusted, as far as the author could, to the taste and spirit of those times, and so may be reckoned a notable piece of the ancient *Hippocratical* pathology. And what is there said of *critical days*, however superficial and precarious, is still far enough from any thing of the *Pythagorean* doctrines of *numbers* and *proportions*. Upon what then is this extraordinary system of *Hippocrates* founded? It seems upon facts, stubborn facts, which neither the distance of time, nor place, nor the art of man can alter. In a word, did not fevers make such and such appearances on such and such days, and end on such and such other days, and that much more frequently than in any other periods? This is a meer question of fact, and, as it were, a piece of natural history; the truth of which is not to be tried by theories and speculative schemes: but either to be laid aside, or confirmed by repeated careful observations,

ſervations, to which alone we muſt appeal in this important article: and if true we are to found our ſpeculations thereon. This is the true and regular method in Philoſophy: and muſt be ſo too in Medicine in as far as we ſhall pretend to raiſe it to the dignity of a Science.

9. This ſcheme, upon being propoſed by *Hippocrates*, immediately prevailed univerſally. It was adopted even by thoſe who in other things were little moved by the authority of the great *Coan*. [a] *Diocles* of *Caryſtos*, a man juſtly famed for his ſingular ſkill and diligence in obſerving nature, gave in to that doctrine. *Philotimus* [b] too wrote of it. And even thoſe, who laid aſide all ſyſtems, and, from their bare obſervation of facts, called themſelves *Empirics*, convinced by what they ſaw, naturally embraced it [c]. *Heraclides* of *Tarentum*, one of the chief of that ſect, treated expreſsly of this ſubject [d]. And *Archigenes* the *Eclectic*, who profeſſed himſelf a true freethinker in Phyſic, addicting himſelf wholly to no particular ſect,

[a] Vid. Gal. de Dieb. Decr. I, 2. 3. 6. 9. 10. 13. II, 5. 13.
[b] Vid. Galen. Ibid. I, 2.
[c] Vid. Galen. Ibid. I, 5. II, 7.
[d] Vid. Galen. Ibid. I, 2.

ESSAY I. but chuſing out of every one what appeared moſt conſonant to reaſon and experience, took up with this part of *Hippocrates*'s ſyſtem [a]. I need not mention *Galen*. His great zeal for the doctrines and honour of his maſter is ſufficiently known. It is perhaps on ſome occaſions greater than what every body will approve of. And ſo it will not be allowed me to found much upon his aſſent; nor conſequently upon that of the phyſicians of the ſucceeding ages, who, perhaps, you will alledge were all ſo tutored and prepoſſeſſed by *Galen*, in whom they put intire confidence, that they were readier to obſerve him than nature, and to wreſt the hiſtories of diſeaſes in ſuch a manner, as to adapt them at any rate to the rules of one, whom they thought infallible.

10. Not but that even in ancient times *Hippocrates* had his oppoſers too. [b] *Herophilus*, a Phyſician of very great fame and merit, wrote againſt his doctrine of *Prognoſticks*; whereof that of *criſes* and *critical*

[a] Vid. Galen. Ibid. I, 2. 10. 13. II, 12. III, 13. de Criſib. III, 4.

[b] Vid. Galen Com. I. in Hipp. Progn. p. 190. De Dieb. Decr. II, 7. Cæl. Aurelian. Chronic. IV, 8. §. 113.

days

days make ſuch a conſiderable part. [a] *Xenophon* too had done ſomething of this kind. No mean man, if, as is likely, he be that great anatomiſt and diſciple of *Eraſiſtratus*, who was among the firſt that wrote a treatiſe concerning *the names of the parts of the human body* [b]. But the moſt eminent of all, who condemned *Hippocrates* in this particular, was the famous *Aſclepiades* [c]. He was originally a Rhetorician; but not ſucceeding well in that trade, he took it in his head to profeſs medicine at *Rome* in a very extraordinary manner, and at a time when novelties began to be much reliſhed. As he took it up at his own hand, it will not be wondered that he had little regard to others who had gone before him in this art, whom he gave out as no better than manſlayers. He was not thoroughly acquainted either with their principles or obſervations. He deſtroyed all the foundations of ancient Phyſic; and, in the ſpirit of a thorough reformer, endeavoured to pull all to the ground; that he might raiſe in its place a new ſyſtem, founded chiefly upon the *Epicurean*

ESSAY I.

[a] Vid. Galen. de Dieb. Decr. II, 7.
[b] Vid. Galen. adſcript. Introd. 10.
[c] Vid. Celſ. Medic. III, 4. p. 121. Galen. de Dieb. Decr. II, 7. Cæl. Aurel. Acut. I, 14. §. 109.

ESSAY I. philoſophy, and embelliſhed with the moſt plauſible reaſons; as juſtly we might expect from one of his education and profeſſion in the arts of ſpeaking and writing well. Thus ſetting out, and accompanying his theory with a great indulgence and tenderneſs in moſt of his practice, he gained a great name; and, amongſt other things, quite ruined with his followers the character of *Hippocrates's periods* and *critical days*. So that we find *Celſus* having no regard to them in the management of fevers; though in other things a great admirer and copier of the venerable author of that doctrine; and who in particular has tranſcribed very many of the *Coan prognoſtics*, concerning the *criſes* and *periods* of diſeaſes.

11. Let us now ſee what reception this *Greek* ſcheme has met with among the moderns. We are the favourites of providence reſerved unto theſe later days of light and knowledge. We are poſſeſſed of the wiſdom of the ancients: we have in our hands the moſt valuable of their treaſures; and have beſides acquired numberleſs additions of our own in all polite and uſeful learning. And in a more eſpecial manner all the parts of

of Medicine have been vaſtly improved ſince the middle of the laſt century. On the contrary in old times the firſt Phyſicians had little or no philoſophy, very little geometry, nor much anatomy: they neither took the body in a chemical nor mechanical view: in ſhort the *Phyſiologia medica* was very ſcanty, and took up but little of their time and pains. Nor did they deal in the ſtudy of Languages, Criticiſms, Poetry, Hiſtory, Mathematics, Natural Hiſtory, Natural Philoſophy, Chemy, Botany, and every thing elſe the modern phyſicians account neceſſary, convenient, or ornamental qualifications. So that having few other helps, and not many avocations, they applied themſelves the more diligently to the careful notice of diſeaſes, their various ſymptoms, changes and periods; ſince it was only upon theſe they were to build a foundation for a regular practice. We are in a very different ſituation. We pretend to know every the leaſt fibre of the animal machine: not a capillary blood veſſel, ſcarce a nervous filament, can eſcape our narrow and accurate inquiries. We know, or think we know, the nature, and underſtand the changes of all the various liquors in the body. We know the form and ſtrength of the ſolids;

ESSAY I.

and can reduce to a calcul the weight, motion, velocity, *&c.* of the fluids. So that we have the animal machine laid open to our view. All theſe are noble advances in theory, and are conſequently conſiderable helps in the practice of Phyſic, if not by an overweaning fondneſs too much relied on. But I fear that in confidence of them we are not at ſufficient pains; or perhaps have not yet ſufficient *data* to determine exactly the nature of diſeaſes, ſo as to manage them in a *ſcientifical* manner, as the improvers on the *Harveian* diſcovery have commonly propoſed: χαλεπον γαρ εϛιν εκλογισασθαι ειδοτα τας ἰδους [a]. We have indeed got ſo much of the true phyſiology of diſeaſes, and ſo many general rules drawn from our eſtabliſhed theories, as to render our practice much eaſier than formerly. But then, truſting too much to theſe rules and theories, our obſervations of particular diſtempers, of their ſymptoms, and periods, and various connexions are ſeldom ſo careful and accurate, as were thoſe of the ancients, who had ſcarcely any thing elſe to do, or to rely on (" *tanto priſcorum cura fertilior, aut induſtria felicior fuit.* ——

[a] Hipp. VI. Epid. VIII, 82.

" *Poſteris*

" *Poſteris laxitas mundi & rerum amplitudo* ESSAY I.
" *damno fuit* [a].)" Add to this much of our time ſpent in learning and cultivating various languages, ſciences and arts, almoſt foreign to Medicine; and which in the preſent imperfection of human nature muſt (except in a few extraordinary geniuſes) rather retard than advance our progreſs in this chiefeſt part of our profeſſion. A diſadvantage from which the ancient *Greeks* were free; and only introduced when Phyſic was ſpread far through the world, and Philoſophy began to be blended with it, and to confound its priſtine ſimplicity.

After all this it will not be wondered at, if in our days the doctrine of *Prognoſtics* be leſs minded than formerly. And beſide that we are not ſo careful as the ancients were in obſerving the true courſe or bent of nature, it may perhaps be alledged we do not follow out that beautiful ſimplicity of practice *Hippocrates* was ſo remarkable for, which *Sydenham* endeavoured to reſtore, and which *Boerhaave* has reduced into a well connected and elegant ſyſtem. Do not we by our complex methods and officious practice ſome-

[a] Plin. Nat. Hiſt. XIV. Procem.

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times so alter the regular course of diseases, and bring on such a train of extraordinary symptoms, that it is impossible to distinguish what is owing to art, and what to Nature? So that it is by no means matter of surprise if, in the midst of our other improvements and embellishments in Physic, the ancient doctrines of *Crises* and *Critical days* be almost lost amongst us, who in health are under such an irregular regimen of diet, and in a morbid state under such an irregular and negligent method of cure. However, notwithstanding all these disadvantages, upon an exact scrutiny I doubt not but we shall find a greater conformity between the appearances of diseases in these our times and climates with the histories and observations of *Hippocrates*, than what one at first would have expected, or most People are ready to think.

12. The great *Bellini*, moved thereto, I suppose, by the irrisistible evidence of the numerous histories of diseases recorded by the ancients, acknowledges [a] the force of

[a] De Urin. p. 25. 27. 36. 41. 53. 56. De Febr. p. 253. 254. 255. 258. 259. 264. 265. 267. 268. 306. 426. De Morb. Cap. p. 468. 573. De Morb. Pect. p. 634. 648. 654.

observation

obſervation in determining the *critical days*, and the times of the maturation, and ſeparation of the morbid humours, and the duration of diſeaſes. And yet [a] he ſeems, inconſiſtently enough, at the ſame time to reject with contempt the *ternary* (he ſhould have ſaid *quaternary*) and *ſeptenary* numbers of *days*; and that truly for a very odd reaſon, as if the ſuppoſing the *day* to conſiſt of more or fewer than 24 hours ſhould ruin the whole ſcheme. A *day* to us in this earth is an unalterable ſpace of time the ſun appears to take in going round the axis of our globe; and conſequently the ſame in a *parallel ſphere*, as in an *oblique* or a *right* one; otherwiſe than what you would be apt to reckon from *Bellini*'s reaſoning.

We are apt to think that the *times* and *periods* of diſeaſes muſt depend upon the ſtate of the ſolids and fluids of the body; as they are diſpoſed to undergo ſuch and ſuch changes: and that theſe muſt vary in the various degrees of the firmneſs, fluidity, ſize, coheſion, *&c.* of their conſtituent particles, according to the ſeaſons of the year, the heat and cold, drineſs or moiſture, and other

[a] De Miſſ. Sang. X. p. 243.

ESSAY I. circumstances of the country where we live. Whence we must conclude it almost impossible the same *periods* and *critical days* should obtain with us in *Britain* or *Germany*, as formerly in *Greece* or *Asia*. All this seems to be very plausible; and upon it Dr. *Pitcairn* [a], a professed disciple of *Erasistratus*, discarded intirely the *Hippocratical days*, alledging it should be next to a miracle if what obtained of old with *Hippocrates* and *Galen* should take place in our age and country.

Indeed even *Galen* [b] himself tells us that the season of the year, the country and age of the patient, all contribute towards the quick progress of the disease. And *Baglivi* [c], a great admirer too of *Hippocrates* and the *Grecian* Physic, acknowleges "In "frigidis, paludosis & Septentrionalibus re- "gionibus raro *crises* perfectæ observantur; "ut *Germani*, aliarumque frigidarum re- "gionum medici abunde testantur." And *Charles* de *Clermont* in his observations on *England* complains, that by reason of the

[a] Elem. Med. I, 7. §. 3. 4.

[b] De Crif. I, 4. III, 4. Vid. & Hipp. II. Prædict. XL, 4. XLIII, 1.

[c] Prax. Med. II, 12. p. 234. I, 15. p. 157. Vide & Pechlin. Obs. Med. II, 17. p. 245.

great

great Irregularities both in diet and practice there is greater confuſion in their diſeaſes, "*ut neque contemplabiles, nec indices, nec* "*medici, neque critici dies obſervari que-* "*ant* [a]." The coldneſs of the climate, and the moiſture of the air contributing likewiſe very much to the ſame effect: "*inde* "*morbi chronici, putridæque febres, & ſine* "*typo* [b]." He takes particular notice of their ſevere and long fevers, "*quas rariſſime* "*apud ipſos perfecta criſis ſolvit* [c]." But notwithſtanding all this, he maintains that among the gentry, who live ſomewhat after the manner of the *French*, there may be obſerved in both the ſame diſeaſes and *critical* turns. "Sane ſi quis gnaviter ac intelli- "genter nobiles *Anglos* curaverit, non ob- "ſcuras ſæpe *criſes* in ipſorum morbis ani- "madvertet, quas in vulgaribus perraras eſſe "omnes fatentur [d]." From all which our countryman Dr. *Cheyne* [e] may ſeem very well to have ſaid that "in this various and "inconſtant climate *periods* and *criſes* are

[a] De Angl. Aer. Aq. &c. p. 38.
[b] Ibid. p. 41.
[c] Ibid. p. 43.
[d] Ibid. p. 48.
[e] Engl. Malad. II, 8. §. 5. p. 199. Of the Gout, §. 9. Vid. & Ketelaer de Aphth. p. m. 16.

ESSAY I. " ſo uncertain and irregular, that we have " nothing but miniatures and models of " them, to what they were obſerved in " eaſtern climates, and orderly people." But let us chiefly conſult the ſagacious, accurate and candid *Sydenham*, to find whether or no any thing of the *Hippocratical* ſcheme ſtill holds true; and if the ſame or nearly the ſame things uſe to happen in *Britain* and theſe northern countries now adays, that fell out in *Greece* and *Aſia* long ago. And after that I believe we will be ready to hearken to Dr. *Freind*'s admonition, when, with a view indeed very different from ours, he takes the pains to warn us, " ne quis ea, quæ de fe- " bribus divine ſcripſit *Hippocrates*, ad nos " minime pertinere arbitretur, veluti alio in " cœlo, alioque hominum genere concluſos [a]." ἐστι δε και εν λιβυη, και εν δηλω, και εν σκυθιη φαινεσθαι τα προγεγραμμενα αληθευοντα σημεια [b].

13. *Sydenham* is allowed by every body to have been, of all the moderns at leaſt, the moſt careful, the moſt induſtrious, and the moſt exact obſerver of diſeaſes, of their periods, conſtitutions, ſymptoms, and all

[a] Com. de Febr. I, p. 5.
[b] Hipp. Præn. XXVII, 5.

other

other circumſtances. After all his moſt careful reſearches he laid it down as a certain principle [a] (therein agreeing very much with *Hippocrates*) that *diſeaſes* are but the efforts of nature to throw off the morbific matter, ſo as to bring the patient to his former health: which in *fevers* is commonly done by ſome eruption or evacuation.

Many and various are the deviations from nature of the liquors of the human body bringing on *fevers*. But the ſame great man has obſerved that they, whether produced [b] by ſome innate contagion, or influenced by the qualities of the ſurrounding air, or by ſome latent indiſpoſition inherent in it, or by ſome other infection, or a combination of ſundry ſuch cauſes; he I ſay obſerved [c] that *fevers* are determined *ferments* or *commotions* [d] in the blood, and apt to be brought preciſely to ſuch and ſuch ſtates, ſo as to conſtitute particular kinds of diſeaſes [e], intirely diſtinct one from another, and duly to

[a] Oper. p. 37. 38. 51. 62. 79. 165.
[b] Ibid. p. 23. 53.
[c] Ibid. p. 51. 52. 53. 88. 89. 90.
[d] Vid. & Aët. Tetrab. V, 70. Rhaſ. de Peſtil. I, 6. Contin. XXX, XIII, 1. p. 419. Avicen. Can. IV, I, IV, 6. Hipp. de Humor. I, 1. III, 105.
[e] Sydenh. Ibid. p. 17, 18, 23. 24. 25. 80.

be

ESSAY I. be characteriſed by a careful and judicious deſcription of the phænomena, that naturally occur in them. He maintains [a] that nature is no leſs regular in producing and carrying on theſe diſeaſes in certain periods of time than in the generation and growth of plants and animals. So that he thinks [b] it neceſſary to claſs diſeaſes, and reduce them to their ſeveral ſpecies in the ſame manner, and with the ſame exactneſs, that the profeſſors of Botany have uſed in ranging their various kinds of herbs and trees.

Thus for example [c] if any body ſhall but duly weigh the *phænomena* that appear in a *quartan ague*; its regular ſeaſon of the year of appearing, its ſettled and unvaried ſymptoms, its conſtant revolutions, as regular as a piece of clockwork [d], its way and times of ending; he, I ſay, who ſhall duly weigh all this, muſt, according to *Sydenham*, as certainly conclude this diſeaſe to be a

[a] Ibid. p. 18. 25. 46. 80. 88. 89. 90. 131. 145. 165. Confer & Galen. de Deib. Decr. II, 2. Pereir. Nov. Med. 58. p. 756. 757. Mead. de Imp. Solis &c. 2. p. 60. 61. 62.

[b] Sydenh. Ibid. p. 13.

[c] Ibid. p. 24. 25.

[d] Confer & Borell. de Mot. Anim. II, 220. p. 278. II, 231. p. 303.

ſpecies

ſpecies by itſelf for the ſame reaſons that he reckons any kind of plants to be a ſpecies diſtinct from all others, becauſe he finds it germinate, and grow, and flouriſh, and die in determined periods, and in a way peculiar to itſelf. There is this only difference [a], that *plants* and *animals* are independent ſpecies or ſubſtances; whereas *diſeaſes*, though ſpecifically different one from another, are intirely dependent on the humours of the body generating them, and whereof they are, as it were, accidents or modifications. Theſe continuing ſuch and ſuch ſpaces of time [b], as the fermentations and depurations in wine, or ale, or cider, or other ſuch natural commotions are performed in determined periods according to their ſeveral natures.

14. We will not pretend to examine diſeaſes in all their various circumſtances; eſpecially that they have not been ſo accurately obſerved or deſcribed by the Writers of the later ages as were to be wiſhed. It ſufficeth to our purpoſe to conſider their *ſtages* and *durations*, and if they terminate in the manner *Hippocrates* bids us expect.

[a] Sydenh. Ibid. p. 25.
[b] Ibid. p. 88.

That

ESSAY I. That is, if ſuch and ſuch *fevers* have their final *criſes* in ſuch a manner, and on ſuch and ſuch *days* more readily than on any other. To determine which it would be beſt to take an exact journal of diſeaſes in various years and ſeaſons: and to take notice if the *epidemic fevers* of given *conſtitutions* obſerve any conſtant rules agreeing with the *Coan* doctrine.

Indeed few ſuch journals have been kept. However let us examine if from the obſervations of *epidemic* and other regular *diſeaſes* furniſhed us by *Sydenham* and ſome few others we may not perceive the ſame tendency of nature in different ages and countries, which gave riſe to *Hippocrates*'s canons.

15. *Fevers* terminating on the VIIth *day* have been very frequent in all ages. *Hippocrates* [a] has often told us that in ſuch on the 4, along with other good ſymptoms, the urine uſed to diſcover the ſigns of a beginning laudable *concoction*.

A. Thus the more moderate and benign *phrenitical fevers* that happened in the au-

[a] Aph. IV, 71. Coac. I, 213. V, 5.

tumn

tumn and winter of the third *Thaſian* conſtitution came to their height on this day [a].

B. *Ramazzini* [b] obſerved a *delirious fever* at *Modena* ann. 1691 ending by a ſweat on the 7 day.

C. And from this he takes occaſion to mention from *Lucian* [c] a very ſtrange *delirious fever* among the *Abderites*, which ended on this day either by profuſe ſweating, or bleeding at the noſe.

D. Dr. *Winteringham* [d] obſerved a ſlight *fever* at *York* ann. 1725. ending in a week.

E. *Galen* [e] alledged that *fevers* have a true and laudable *criſis* oftener on the 7, than on any other day. Which, as far as I have had opportunity to obſerve, holds ſtill true enough, eſpecially in country people, who live ſimply, and get no artificial diſturbance in their diſeaſe. But they are very ſubject to relapſes: I ſuppoſe from cold, over-eating, or ſome other error of that kind, flowing from a perſuaſion of their being perfectly well and out of danger.

[a] I. Epid. II, 164.
[b] Conſt. Epid. Urb. 1691. §. 34. p. 104.
[c] De Conſcrib. Hiſt. in initio. p. 600.
[d] Com. Noſol. p. 81.
[e] De Dieb. Decr. I, 2. 5. 7. 10. II, 8.

ESSAY I.

F. *Galen* himſelf ſaid [a] he could not tell how many he had ſeen *judged* on the 7 day. And in particular he lets us know of above 400 patients he had in one ſummer under acute fevers, who all got a *criſis* on the 7 or 9 *day*.

G. In another year [b] ſome were *judged* on the 14, ſome on the 20, commonly after an intermiſſion and relapſe: but moſt of them after an hæmorrhage on the 5, got a *criſis* on the 7 or 9, as in the forementioned year.

H. *Hippocrates* reckons [c] in general the 7 and 9 *day* as the moſt common terms of *ſummer bilious fevers*. And in particular he gives [d] an account of epidemic *ſummer fevers* of a certain conſtitution, that were for the moſt part tedious and uncritical. However ſome few of them ended on the 7 and 9, and others on the 11, 14, and 17.

I. At *Wratiſlaw* [e] in ſummer ann. 1699. there aroſe an *ardent fever* wherein the younger ſort uſed to be *judged* about the 7

[a] Ibid. II, 7.
[b] Ibid.
[c] De Affect. XIII, 9.
[d] VII. Epid. I, 2. 3.
[e] Conſt. Epid. Uratiſl. 1699. p. 329.

day

day by an hæmorrhage of the noſe. The elderly folks got their *criſes* by copious ſweats on the 14. ESSAY I.

K. Even *Bellini* [a] agrees with others in aſſigning to *fevers* certain determined *periods*. "*Febris continens pura* durat 7 *dies*, *no-*" *tha* 14." And again, "*Febres puræ* "*ardentes* plerumque 7, *non puræ* 9, 11, "14, *&c. diebus* durant [b]." Which probably he took from what *Hippocrates* [c] ſaid of the καυσος, and πυρετος καυσωδης.

L. *Fevers* with a pain of the head moderate in the beginning, but increaſing on the 4 and 5 *day*, go off on the 7 [d].

M. *Fevers* with ſhiverings are *judged* chiefly on the 5, 7 and 9. But we are to be on our guard till the 14 [e].

N. The *Jaundice* appearing in a *fever* before the 7 day is bad [f], if the patient be not relieved ſome other way [g]: but is critical if on the 7, 9, 11 or 14, without hardneſs in the right hypochonder [h].

[a] De Febr. p. 254. 306.
[b] Ibid. p. 255.
[c] De Affect. XI, 12. XIV, 7. De Criſ. IV, 3. Coac. I, 190.
[d] Præn. XXV. 7. De Criſ. II, 2.
[e] VII. Epid. XL, 22.
[f] Aph. IV, 62. De Criſ. VIII, 20.
[g] I. Epid. II, 120.
[h] Aph. IV, 64. Coac. I, 172. De Criſ. III, 5. 18. IV, 11.

ESSAY I.

N *. In like manner *Ketelaer* obſerves that in the aphthous fever if the *Sprouw* appear before the 7 day it is bad, and not ſo promiſing as if the eruption were delay'd untill the 7 or 9 [a].

O. Hæmorrhages of the noſe happening on the 7, 9, (11) and 14 *days* commonly carry off the fever [b].

Other diſeaſes too, thoſe eſpecially of an inflammatory and feveriſh nature, have certain *maturations*, *periods* and *criſes* about ſuch and ſuch ſettled times.

P. Thus the 7 *day* is [c] very frequently the term of a *Pleuriſy*, whereon we may expect a *criſis*, if the ſpittings appear concocted on the 3. If this be a little later [d] the *criſis* is protracted till the 9 or 11.

Q. So too this diſeaſe goes off on the 7, if about the 3 *day* a looſeneſs come on bloody and bilious, and then ſerous together with eaſy ſpittings [e].

[a] De Aphth. p. 20. 30. 36.
[b] Coac. I, 222.
[c] Aph. I, 12. Coac. III, 132. II. De Morb. XL, 10. III. De Morb. XXI, 33. De Affect. VIII, 18. Aret. de Acut. Cauſ. &c. I, 10.
[d] Galen. Com. in Aph. I, 12. Boerh. Aph. §. 888, 6.
[e] Aret. Ibid. Boerh. Ibid. §. 888, 3.

R. And

R. And alſo if in the very beginning the tongue appear bilious the patient is judged on the 7 *day* [a].

S. In ſome *plurifies* [b], beſide other ſymptoms, the ſpittle is white and bilious, a pain in the groin, and the urine bloody: if the *fever* go off on the 7 the patient is well, otherwiſe the diſeaſe laſts till the 11 or 14 whereon many die.

T. If with ſpittings of various kinds (παμποικιλαις πτυσιαις) the patient eſcape death on the 3 or 5, and that without any conſiderable alleviation, a ſuppuration begins on the 7, or 9, or 11 [c].

V. In a *Peripneumony* the moſt remarkable *critical days* are the 7 and 14, whereon the patients either die or recover; and the 9 and 12, whereon there happens ſometimes a ſuppuration [d].

X. In this diſeaſe yellow ſpittings mixed with ſome blood in the beginning is beneficial, but if this happens not till the 7 *day* or afterwards, it is not ſo ſafe [e].

[a] Coac. III, 129. De Loc. in Hom. XXIV, 6.
[b] II. De Morb. XL, 10.
[c] Coac. III, 124. III. De Morb. XXI, 23.
[d] II. De Morb. XLIV, 16. De Loc. in Hom. XXV, 6.
[e] Præn. XIII, 12. Coac. III, 147. Celſ. Medic. II, 8. p. 70, 34.

ESSAY I.

Y. However at *Hildeſheim* in the ſpring ann. 1696. there were *fevers* not diſcovering any *pleuritick* or *pectoral* ſymptoms in the beginning, which yet about the 7 *day* grew eaſier by a cough and expectoration coming on [a].

Z. At *Utretcht* in *March* 1729. there was an epidemic *Peripneumonia* which commonly laſted 7 or 8 days [b].

AA. The *Hepatitis* is for the moſt part judged in 7 *days*, ſo that it may be known whether it ſhall be deadly or no [c].

BB. And this *Hippocrates* [d] reckons the ſhorteſt term of a *Phrenitis*. Though ſometimes it laſts till the 11.

CC. The τυφος of *Hippocrates*, a dangerous diſeaſe, uſed to be *judged* in 7 *days*, or 14. Sometimes it was protracted to the 24 [e].

DD. In the epidemic *petechial fever* at *Cologn ann.* 1672. *&c.* when well managed, the flecks appearing about the 3 day, the patient had a ſalutary criſis by a ſweat on the 7 [f].

[a] Behrens Hiſt. Epid. Hildeſ. §. 11. p. 297.
[b] Muſchenbr. in Phil. Tranſ. 425. p. 369.
[c] De Int. Affect. XXX, 30.
[d] De Affect. X, 18.
[e] De Int. Affect. XLII, 14. 15. XLIII, 18. 19.
[f] Donckers de Febr. Punct. p. 3. 99. 287.

EE. But

EE. But in the grand epidemic *petechial fevers* in *Italy ann.* 1505. and 1528. the eruption fell out ſometimes about the 4 ſometimes the 7 [a].

FF. And in that one about *Modena ann.* 1692 &c. when undiſturbed by any medical practice, they uſed to recover by the eruption of the ſpots about the 7 day [b].

GG. The periods of chirurgical diſeaſes cannot well be defined. And yet the ſucceeding writers in Surgery have unanimouſly adopted the terms aſſigned by *Hippocrates* for the healing of *diſlocations* and *fractures* of Bones, which, as being commonly taken notice of, we may be allowed to paſs over. But among other obſervations of this ſort, and belonging alſo to the doctrine of *fevers*, that moſt careful and diligent man tells us, that thoſe who have their bones broken are ready to fever on the 7 *day*; or ſooner if the weather be very warm, or the fracture very great [c].

HH. And in wounds of the head a *fever* is often fatal coming on upon the 4

[a] Fracaſtor. de Morb. Contag. II, 6.
[b] Ramaz. Conſt. Epid. 1692 &c. §. 25. p. 112.
[c] VII. Epid. XIX, 15.

ESSAY I.

day, and the 7, and the 11. That which begins on the 4 is *judged* commonly on the 11: that which begins on the 7 comes to the 14 or 17: but the fever beginning on the 11 is judged on the 20 [a].

Yea this 7 *day*, and others akin to it may have sometimes proved unlucky on other occasions, sometimes from the malignity of the disease: and often under officious practice and other wrong management.

II. Dr. *Morton* [b] tells us that the Συνεχης of *England*, which came on in autumn 1658 and continued *ann.* 1659, 1660 *&c.* was now and then attended with some of the violent symptoms of the spurious kind, and carried off the patients on the 7, 9 or 11 day: and frequently turned continal and killed on the 17 or 21.

KK. At *Mansfeldt ann.* 1697 in *February* there came in a *petechial fever*, in which the spots appeared on the 2 and 3 day, attended with great decay of strength and malignity. On the 5 hæmorrhages of the nose in men, and the *menstrua* in women

[a] II. Præd. XXIII, 5.
[b] Pyretol. II, Append. p. m. 235.

burst

burſt out, ſure forerunners of death. This commonly happened on the 7 [a].

LL. In the *Lower Hungary* in winter 1711 there was an efflorescent fever *(purpura rubra)* of a malignant nature, chiefly affecting children, and killing on the 5 and 7 *day* [b].

MM. And in the ſpring of the following year 1712 were *fevers* with ravings, likewiſe fatal on the 5 and 7 *day* [c].

NN. And at *Paris* in the beginning of the year 1576 thoſe who had weak and ſpoilt lungs fell into *fevers*, *pleuriſies* and *peripneumonies*, which brought on death in 5 or 7 *days* [d].

OO. Thus in that kind of *pleuriſy* wherein the ſhoulders and back are particularly affected, if in the beginning the patient ſpit a little, loſes his ſtrength, on the 3 or 4 day piſſes bloody urine, he dies on the 5 or 7 [e].

PP. Yea generally if the ſymptoms come on unfavourably the patients often die on

[a] Stagman. Hiſt. Epid. Mansf. ann. 1697. p. 315.
[b] Genſel. Conſt. Epid. Hung. 1711. p. 798.
[c] Id. Ibid. 1712. p. 799.
[d] Ballon. Epid. II, p. 150.
[e] II. De Morb. LIV, 8. III. De Morb. XXI, 8.

ESSAY I. the 7 day both in a *pleurisy* and *peripneumony* [a].

QQ. *Pleurisies* easy in the beginning, but growing more violent on the 5 or 6 *day*, often prove fatal on the 7 and 12 [b].

RR. In a *convulsion* or in a *repletion* of the lungs the patients often die on the 4 *day*, sometimes the 7. If they escape this they are safe [c].

SS. A *squinance* falling upon the lungs kills in 7 days; or leaves a suppuration in them, if they happen not to be relieved by phlegmatic spittings [d].

TT. Pain in the ear with a sharp *fever* kills the younger sort in 7 *days* or sooner, if they be not relieved by some flux from the ear, or blood from the nose. Its progress is slower and less dangerous in elderly people [e].

VV. Just so in *cephalalgic fevers* the 7 *day* is often fatal, if a flux by the ears or

[a] II. De Morb. XLIII, 16. III. De Morb. XIX, 16. De Int. Affect. VIII, 16. De Loc. in Hom. XXV, 6. Aret. de Acut. Caus. &c. I, 10. II, 1.

[b] Coac. III, 139. III. De Morb. XX, 7. Boerh. Aph. 901.

[c] II. De Morb. I, II, 25. LVI, 9. III. De Morb. VII, 18.

[d] Aph. V, 10. Coac. III, 105. II. De Morb. XXVII, 15. Cels. Medic. II, 7. p. 64, 8.

[e] Præn. XXII, 11. Coac. II, 59.

noſe do not prevent it [a]. In a more violent ſort they die the 5 or 6 [b].

XX. Who of a ſudden take a pain in the head, and immediately become mute and ſnoar (that is, as I take it, *apoplectic*) they die in 7 days, if they do not take a fever [c].

YY. The *Lethargy* kills in 7 *days*. If the patient eſcape theſe he is ſafe for that time [d]. But ſtill liable to a ſuppuration in the breaſt [e].

ZZ. In the *Hickup fever* attended with bad ſymptoms they die on the 7 *day* [f].

AAA. A *Volvulus*, if not cured, readily kills on the 7 day [g]. And ſo likewiſe does that which comes upon a *ſtrangury*, except along with a fever a flux of urine bring relief [h].

16. Every body knows of what great force the ancients reckoned the XIV day in

[a] II. De Morb. XIV, 5. XVI, 11. III. De Morb. II, 5. VIII, 3.
[b] II. De Morb. XVII, 7.
[c] II. De Morb. XXI, 10.
[d] II. De Morb. LXIII, 12.
[e] Coac. I, 197.
[f] II. De Morb. LXII, 7.
[g] De Affect. XXII, 13.
[h] Aph. VI, 44. Coac. III, 314.

the

ESSAY I. the *criſes* of *fevers*, and the moſt ordinary period of *acute* diſeaſes [a], the *index* whereof they found to be the 11.

A. We have had occaſion to mention ſome ſuch *criſes* already, §. 15. G. H. I. K. M. N. O. S. V. CC. HH; and now we may add more.

B. In the 3d *conſtitution* in *Thaſus* deſcribed by *Hippocrates* moſt of the *mid-winter ardent phrenitical fevers* ſeemed to go off on the 5, returned on the 10, and were finally cured on the 14 *day* [b].

C. One of the ſpecies of the Νσημα παχυ in *Hippocrates*, which ſeems to be a kind of *delirious fever*, is judged in 14 *days*. A relapſe in 7 [c].

D. The author of the 2d of *the Epidemics* aſcribed to *Hippocrates* tells us that the ſummer fevers he obſerved in Perinthus were *judged* on the 14 [d].

E. If the tongue appear very black, there will be a *criſis* on the 14 *day* [e].

F. And in *fevers* thoſe who begin to have a pain of the head *&c.* on the 5 get a *criſis* of the diſeaſe on the 14 [f].

[a] Aph. II, 23. Coac. I, 211. De Criſ. IV, 12.
[b] III. Epid. II, 202.
[c] De Int. Affect. LI, 46. 49.
[d] II. Epid. III, 18.
[e] Coac. II, 139.
[f] Præn. XXV, 9.

G. *Gomez*

G. *Gomez Pereira*, a very eminent Phyſician in *Spain*, when learning was diffuſing itſelf through *Europe* in the beginning and middle of the 16 century, was at more than ordinary pains in obſerving the courſe and genius of *epidemic* diſeaſes, and warmly recommended the ſtudy thereof to others [a]. And he found the *ardent fevers ann.* 1528. and 1556. to be *judged* on the 14 *day*. Inſomuch that ſome who were free from their fever on the 7 or ſooner, did all inevitably (even though Medicines had been given to prevent it) ſuffer one or two relapſes of a benign kind, to accompliſh the due term of 14 *days* [b].

H. He obſerved likewiſe the *continued remitting tertians* to end in 14 *days* [c].

H*. And at *Utrecht* in *September* 1728. there appeared a very mild kind of double tertians, eaſily cured and not laſting beyond 14 days [d].

H**. A little before this about the end of *July* and beginning of *Auguſt* there had been pretty frequent violent putrid [e] fevers,

[a] Nov. Med. 35. p. 537. 538.
[b] Ibid. 40. p. 595. 596. 597.
[c] Ibid. 37. p. 560.
[d] Muſchenbr. Ephem. Ultraj. 1728. p. 683.
[e] Ibid.

diſcovering

ESSAY I. diſcovering the ſigns of concoction about the 11 day; whence, the diſeaſe declining, a criſis by urine relieved the patient in 14 days. In the few who died, the ſymptoms grew worſe after the 10 day, and thence increaſing killed commonly before the 15.

I. But the moſt pregnant inſtances of *fevers* ending about this term may be found in *England*, irregular *England*, wherein it is pretended that neither the weather, nor the people, nor diſeaſes obſerve any regular type or courſe. But, in contradiction to this ordinary aſſertion, we muſt be allowed to obſerve, that moſt of *Sydenham*'s *fevers* had a due *criſis* on the 14 day. Thus it happened in that *continued depuratory fever*, as he calls it, which reigned at *London ann.* 1661, 1662, 1663, 1664[a], the moſt remarkable and moſt regular he ever met with[b]. Indeed if the *fever* towards the end of it was kept too much down, he thinks it no wonder it ſhould have laſted to the 21 *day* or longer[c]. On the contrary however ſometimes by this method it evaniſhed before

[a] Oper. p. 62. 63. 64. 65. 70. 88. 105. 253. 316. 575.
[b] Ibid. p. 50. 250. 251. 316. 317. 574.
[c] Ibid. p. 62.

its

its ordinary term, yet then by a relapſe it was ſure to accompliſh its due courſe of 14 days[a], as we juſt now obſerved from *Pereira* of the *epidemic fevers* in *Spain ann.* 1528 and 1556. ESSAY I.

K. He farther obſerved a ſurpriſing ſimilitude and, as it were, kindred between the *continued* and *intermittent epidemic fevers*, which appear at the ſame time[b]: and in particular between this *continued depuratory fever*, and its concomitant *autumnal quartan*[c]: which though it laſted about half a year, yet ordinarily, taking all the paroxyſms together, uſed exactly to fill up likewiſe the ſpace of 14 *days*. "Neque enim citius aut "tardius maſſa ſanguinea in humano corpore "ordinario repurgatur, ſi negotium naturæ "permiſeris; haud ſecus ac pomatium ſuam, "vinum atque cereviſia ſuam ac peculiarem "habet periodum qua depurentur."

L. The *continued fever* too *ann.* 1673, 1674, 1675, though eſſentially differing from the former, affecting chiefly the head and nervous ſyſtem, yet it agreed with it in this particular, that, when right managed, it

[a] Ibid. p. 63.
[b] Ibid. p. 49. 88. 316. 317.
[c] Ibid. p. 88. 89.

uſed

ESSAY I. used to leave the patient on the 14 *day*; though sometimes, being obstinate, it lasted till the 21 [a].

M. So likewise the *fever* of the *morbillous* kind in the beginning of the year 1674 used to wear out 14 *days*, sometimes longer [b].

N. The *epidemic remittent fever* at *York ann.* 1716 was judged by a sweat on the 14 day [c].

O. At *Wratislaw* in the spring *ann.* 1701 there was an *epidemic semitertian* that went off by a *diarrhœa* in 14 or 20 *days* [d].

P. In the *morbus Hungaricus* or malignant *camp fever*, which shewed itself most remarkably in *Hungary ann.* 1566, according to *Jordanus*'s account some recovered on the 14, others not till the 20 [e].

Q. *Baglivi* says that most acute diseases are carried off about the 7 or 14 *day*, if not disturbed by an undue and officious application of remedies [f]. He himself used to get the better of these which, from the great

[a] Ibid. p. 221. 222.
[b] Ibid. p. 233.
[c] Winteringh. Com. Nosol. p. 33.
[d] Const. Epid. Uratisl. 1701. p. 338.
[e] De Pest. I, 19. apud Sennert. de Febr. IV, 14. p. 839.
[f] Prax. Med. V, 9. p. 65.

crudities in the *primæ viæ*, he calls the *Roman meſenteric fevers*, about the 14 day, or at moſt about the 21 [a]. Though theſe he found to be leſs diſpoſed to a critical regularity than what he reckoned moſt other fevers to have [b].

R. But a *criſis* on the 14 is not always ſalutary. Beſide what we have already had occaſion to obſerve §. 15. S. V. CC. HH. *&c.* and ſhall take notice of by and by, it often proved fatal to thoſe who laboured under an epidemic *ardent fever* at *Utrecht* in *January ann.* 1729 [c].

S. There was a *Catarrhous fever ann.* 1557 obſerved by *Forreſtus*, wherein many died againſt the 9, ſome about the 14; who eſcaped to the 17 were ſafe [d].

T. In the epidemic *bilious fever* at *Piſa ann.* 1661, if they were not happily relieved by a diarrhœa, they died againſt the 14 or ſooner, as on the 10 or 12 [e].

V. And *Morton* tells us that the *London dyſenteric* Συνεχης *ann.* 1666 carried off many

[a] Epiſt. ad Andry. p. 707.
[b] Prax. Med. I, 9. p. 52. 53. 66. 67.
[c] Muſchenbr. in Phil. Tranſ. 425. p. 264.
[d] Obſ. Med. VI, 1. p. 188.
[e] Borell. apud Malpigh. Vit. Poſth. p. 21. 22.

ſooner

ESSAY I. sooner or later, that is on the 14, 17 or 21 day [a].

X. The 14 is likewise very often a *critical day* in other inflammatory diseases. Thus *Pleurisies*, which are easy in the beginning, but grow sharper from the 7 and 8, have a favourable crisis on the 14 [b].

Y. If the spittings come not till after the 4 *day*, we are not to expect a *crisis* before the 14 [c].

Z. If on the 7 or subsequent days a looseness come on bloody and bilious with laudable spittings, the patient is cured on the 14 day [d].

AA. A livid blister appearing on the tongue in the beginning shews the disease will be severe. The crisis happens on the 14 [e].

BB. Those who have bilious spittings, likewise turning purulent on the 7 or subsequent days, commonly die on the 14 [f].

[a] Pyretol. II. Append. p. 237.
[b] III. De Morb. XX, 12.
[c] Coac. III, 132. III. De Morb. XXI, 33. De Affect. VIII, 18. Galen. Com. in Aph. I, 12.
[d] Aret. De Acut. Caus. &c. I, 10.
[e] Coac. III, 130. III. De Morb. XXI, 26. 30.
[f] Præn. XIII, 13. XIV, 5. Coac. III, 153. 155. 160. II. De Morb. XLI, 14. Cels. Medic. II, 6. p. 56, 6. Aret. de Acut. Caus. &c. I, 10.

Yea

Yea if theſe ſpittings come very unfavorably with other bad ſymptoms, the patient dies even before the 14, as on the 9 or 11 [a].

CC. Bloody and dark coloured urine with a confuſed ſediment for the moſt part portends death on the 14 [b].

DD. Thus we ſee how very often the 14th day proves *critical* in a *pleuriſy* [c]. And after the ſame manner by *Hippocrates*'s obſervations a *peripneumony* is often terminated too in 14 days by death or recovery [d].

EE. This is confirmed by more recent examples. We find in Dr. *Muſchenbroek*'s journal that in *March* 1729 there aroſe a ſevere epidemic *peripneumony* laſting juſt 14 days [e].

FF. And in a *peuriſy*, if there be not an expurgation by ſpitting on the *critical days*, or the patient otherways cured before the 14, he readily falls into an *empyema* [f].

[a] Præn. XV, 12. Coac. III, 161.
[b] Coac. V, 37.
[c] Vid. & De Affect. VIII, 18.
[d] De Dieb. Jud. VIII, 17. II. De Morb. XLIII, 2. 16. LXI, 10. III. De Morb. XVI, 21. De Affect. IX, 13. De Int. Affect. IV, 10. V, 17.
[e] Phil. Tranſ. 425. p. 369.
[f] Aph. V, 8. Præn. XIV, 1. Coac. III, 162. I. De Morb. XI, 6. XXIII, 16. De Affect. VIII, 20. Aret. De Acut. Cauſ. &c. I, 10. Boerh. Aph. §. 894.

ESSAY I. The danger of falling in the ſame manner into an *empyema* continues longer in a peripneumony, the *criſis* of which is ſometimes lengthned out till the 21 or 22 day[a].

GG. A *Tubercle* (φυμα) in the lungs continues inflamed 14 days[b].

HH. At *Utrecht* in the beginning of the year 1729 came in *anginous fevers*, which uſed to diſappear on the 5 day; but ſometimes returning about the 7 were finally cured on the 14 from the beginning[c].

II. But in *Dublin ann.* 1693 there was an epidemical *catarrhous fever*, or *cold* vaſtly more irregular, which, when moderate, uſually was over in 8 or 10 days. But in thoſe in whom it roſe to a greater height it continued a fortnight, 3 weeks, and ſometimes above a month[d].

KK. *Hippocrates* ſays that in a *Jaundice*, if they die not in 14 days, they commonly recover[e].

[a] Præn. XIV, 1. Coac. III, 162. De Dieb. Jud. VIII, 17. I. De Morb. XXIV, 7. 10. III. De Morb. XVI, 21. 31. 34. De Affect. IX, 13. 15. Boerh. Aph. §. 633.

[b] II. De Morb. LV, 5.

[c] Muſchenbr. in Phil. Tranſ. 425. p. 363.

[d] Molyneux in Phil. Tranſ. Abr. III. p. 272.

[e] De Dieb. Jud. VII, 9. III. De Morb. XII, 11. De Int. Affect. XXXVIII, 12. 19.

LL. No body would expect any orderly type or regularity in that wild, unmanageable and proteiform diſeaſe the *Gout*. And yet the careful and exact *Sydenham*, who had often experienced it in himſelf, found that in the more vigorous and hale conſtitutions it was commonly made up of a certain number of particular paroxyſms, ſo as to be accompliſhed in 14 days [a]. Something like to which I think I have had occaſion likewiſe to obſerve. But we are not to expect any great uniformity in this matter. *Sydenham* himſelf allows that in the more aged, broken and infirm people it may laſt 2 or 3 months [b]. And, according to *Hippocrates*, *podagrical* diſeaſes, the inflammation going off, are ſettled in 40 days [c]. And he aſcribes the ſame duration to the Sciatick in young men [d].

17. A. In *fevers* and other ſimilar diſeaſes the xx (or xxi) is a very powerful critical day. Some of theſe *fevers*, which in

[a] Oper. p. 438. 632. Vid. & Cheyne of the Gout. §. 8. p. 8.

[b] Ibid. p. 438. 440. 633.

[c] Aph. VI, 49. De Criſ. VI, 3. Vid. & Celſ. Medic. IV, 24. p. 240, 2.

[d] II. Præd. XLV, 12.

ESSAY I.

their ordinary courſe ſhould end in a fortnight, are carried on farther to that time, as was remarked of *Sydenham*'s great and cardinal *depuratory fever ann.* 1661, 1662, 1663, 1664; as alſo of that more inflammatory one *ann.* 1673, 1674, 1675; See §. 16. I. L. So ſometimes the *peripneumonia* §. 16. FF. So likewiſe the *Wratiſlaw Semitertian ann.* 1701 §. 16. O. So the *Morbus Hungaricus* §. 16. P. So *Baglivi's Roman Meſenterick fevers* §. 16. Q. And ſo of one of the years *Galen* ſpeaks of §. 15. G. And ſo too of the fatal end of *Morton's London* Συνεχης *an.* 1558, *&c.* §. 15. II. and of the *Dyſenteric* Συνεχης *an.* 1666 §. 16. V.

B. The autumnal and winter *phrenitical fevers* of the 3d *conſtitution* in *Thaſus* deſcribed by *Hippocrates* were for the moſt part judged on the 11, but in ſome not till the 20 day [a].

C. In the ſame conſtitution there appeared *fevers* with *parotid* ſwellings *judged* on the 20 day [b]. But ſome of theſe, having a *criſis* on the 7, relapſed after an intermiſſion of 9 days, and were judged on the 4

[a] I. Epid. II, 163.
[b] Ibid. 196.

of

of this ſecond fever, which falls on the 20th from the beginning [a]. And others had a *criſis* on the ſame 7 day, an intermiſſion for 6 days, and then, relapſing on the 14th, got a final criſis on the 7 of this new fever, or the 20 from the beginning [b].

D. Much after the ſame manner ſome of the midwinter *phrenitical fevers* grew eaſy about the 11, returned on the 14, and ended critically on the 20 [c].

E. In the firſt *Thaſian conſtitution* the *fevers* had been of a much ſlower kind. In ſummer and autumn the ſhorteſt of them were judged about the 20 day: moſt of them continued till about the 40, many till about double that time [d].

F. At *Wratiſlaw ann.* 1699 there was an epidemic *petechial fever*, which reached to the 21, now and then to the 40; ending ſometimes, though ſeldom, by hæmorrhages, ſometimes by an abſceſs, often by ſweats, but moſt commonly by ſweats and a looſeneſs together [e]. N. B. The ſpots appeared about the 4, 7, yea alſo

[a] Ibid. 198.
[b] Ibid. 199.
[c] Ibid. 205.
[d] I. Epid. I, 59.
[e] Conſt. Epid. Uratiſl. 1699. p. 323.

ESSAY I. the 11 day, but without any alleviation of the diſeaſe. Sweats in the beginning were of no benefit; but after the 4 day, about the 7, 11, *&c.* they portended a happy exit.

G. the *putrid fever* at *York ann.* 1720 laſted till the 20th day, ſometimes longer [a].

G*. At *Utrecht* in *December ann.* 1728 there were ſome continued ardent fevers ſhewing critical urine after the 10th day. They kept pretty uniform for 14 or 15 days; whence, growing eaſier, they went quite off on the 20th day, though leaving the patients very weak [b].

H. In *Ophthalmias*, attended with certain circumſtances, we may expect a *criſis* in 20 days, or 40, or 60 [c]. But the moſt kindly ſort may have it on the 7th [d]. This however is ſomewhat too vague and uncertain.

I. In a *Dorſal pleuriſy* if, beſide other bad ſymptoms, there be a looſeneſs of green

[a] Winteringh. Com. Noſol. p. 51.

[b] Muſchenbr. Ephem. Ultraj. 1728. p. 684.

[c] II. Præd. XXVIII, 6. Celſ. Medic. VI, 6. p. 347, 13.

[d] II. Præd. XXIX, 5.

and fetid bile &c. the patient dies on the 20th or 21ſt day [a].

K. A hard ſwelling (οιδημα σκληρον) in the hypochonders continuing beyond 20 days along with the fever, ſignifies a ſuppuration [b].

L. In the *Hickup fever* the *ſuppuration* comes on about the 20th *day* [c].

M. *Defluxions* into the *thorax* ſuppurate in 20 or 21 *days* [d].

N. If from the beginning of a *pectoral ſuppuration*, there be a ſharp pain with a cough and *dyſpnæa*, we may expect the burſting of it before, or about the 20 day. But if theſe ſymptoms be later of coming on, ſo will the eruption be later, as about the 40 or 60 day [e].

18. A. The IX too and XI are frequent, and commonly good critical days. We have already had ſeveral inſtances of this. As when in the *fevers* of certain *conſtitutions*

[a] Coac. III, 125. II. De Morb. XLII, 14. III. De Morb. XXI, 20.
[b] Præn. VI, 4. Coac. II, 228.
[c] II. De Morb. LXII, 9.
[d] Aph. VII, 38. I. De Morb. XI, 3.
[e] Præn. XV, 16. XVII, 6. 7. Coac. III, 199, &c. Celſ. Medic. II, 7. p. 65, 19. p. 66, 9.

ESSAY I. all *Galen*'s patients got their *crises* on the 7 or 9 day; §. 15. F. G. So some of *Hippocrates*'s were judged on the 9 and 11 *&c.* §. 15. H. M. They are among the *critical terms* of some *fevers* assigned by *Bellini* after *Hippocrates*; §. 15. K. They are *critical* in a *Phrenitis*; §. 15. BB. In the *Jaundice fever*; §. 15. N. And for *hæmorrhages*; §. 15. O. And in *Pleurisies*; §. 15. P. S. T. §. 16. BB. And *Peripneumonies*; §. 15. V. However they have been fatal in some *fevers*; §. 15. HH. II. §. 16. S. BB.

B. *Galen* has given us a fine observation of the virtue of the 11th, telling us that once in an autumn all his patients got a happy *crisis* on that day [a].

C. And *Hippocrates* himself had left behind him an observation much of the same nature concerning the *autumnal fevers* of the third *constitution* in *Thasus*, which ended by a crisis on the 11 day [b].

D. And already [c] we had occasion to take notice that most of the *autumnal* and *winter phrenitical fevers* of this *constitution* were

[a] De Dieb. Decr. II, 7.
[b] I. Epid. II, 147.
[c] §. 17. B.

judged

judged on the 11, though ſome of them laſted till the 20.

E. In *fevers* thoſe who have the pain of the head &c. on the 3, and increaſing on the 5, are free againſt the 9 or 11 [a].

F. At *Hildeſheim* in the ſpring *ann.* 1696 there were epidemic *fevers* with ſlight deliriums in the beginning, which terminated on the 9 either in death or recovery [b].

G. Beſide what we have already had occaſion to obſerve concerning the periods of a *pleuriſy* on theſe days, we may add from *Hippocrates* that *pleuriſies* of a bilious and ſanguineous nature have for the moſt part a ſalutary *criſis* on the 9 or 11 day [c].

H. If in a *pleuriſy* the tongue appear bilious about the 3 or 4 day, we may expect a *criſis* about the 9 [d].

I. One of the kinds of *Hippocrates*'s ἠπαλιτις is commonly mortal in 11 days [e].

19. A. Many fevers end on the XVIIth day, commonly well, ſometimes not ſo a-

[a] Præn. XXV, 8.
[b] Behrens Conſt. Epid. Hildeſ. §. 11. p. 297.
[c] Coac. III, 137. III. De Morb. XX, 5.
[d] Coac. III, 129. De Loc. in Hom. XXIV, 6.
[e] De Int. Affect. XXXII, 14.

greeably.

ESSAY I. greeably. Some examples we have already had occaſion to mention. Some of *Hippocrates*'s patients got free of their diſeaſes on that day; §. 15. H. It proved a ſafe harbour to *Forreſtus*'s patients in the great epidemical *catarrhous fever ann.* 1557, wherein many were ſhipwrecked on the 9 and 14; §. 16. S. But many of *Morton*'s patients in the *London συνεχης ann.* 1658, *&c.* and *Dyſenteric fever ann.* 1666, were not ſo lucky on this 17 day; §. 15. II. §. 16. V.

B. In the ſecond *Thaſian conſtitution* of *Hippocrates* the autumnal *ardent fevers* were attended with no bad ſymptoms nor bad ſucceſs, and were judged in 17 days [d].

C. And in the third *conſtitution* he gives us an account of a ſet of *fevers* with various *criſes*, *periods* and intermiſſions, but with a ſurpriſing harmony all ending *critically* on the 17 day from the beginning [b].

D. Under this head we may perhaps claſs an obſervation of *Hippocrates* that a *peripneumony* laſts ſometimes 18 days [c].

[a] I. Epid. II, 31.
[b] Ibid. 180——193.
[c] II. De Morb. XLIII, 27. LXI, 11. III. De Morb. XVI, 31. De Affect. IX, 13.

20. Some

20. Some *fevers* both *epidemic* and *intercurrent*, and other very acute diſeaſes are exceeding ſhort, and get their critical evacuation, or at leaſt come to an end in a very little time. We ſhall have occaſion afterwards to mention the ſudden ſtrokes of ſome *peſtilences*; at preſent we ſhall chiefly conſider ſome of thoſe ſhort diſeaſes of a leſs malignant or leſs contagious kind.

A. We have already had examples of ſome *critical* appearances happening very ſoon: as on the 2 day; §. 16. KK. On the 3 day; §. 15. T. DD. KK. OO. §. 18. E. H. On the 4 day; §. 15. EE. HH. OO. RR. §. 17. C. F. §. 18. H. On the 5 day; §. 15. M. T. KK. LL. MM. NN. OO. QQ. §. 18. E. And afterwards in the examination of ſome particular diſtempers more of this kind may caſt up.

B. There have been *Ephemeras* or *fevers* of *one* day obſerved in all ages; from whence *Diocles* took occaſion to reckon the firſt among the *critical days*. But *Galen*[a] is unwilling to allow this; foraſmuch, it ſeems, as theſe *fevers*, being produced com-

[a] De Dieb. Decr. I, 9. II, 5. III, 8.

monly

ESSAY I. monly by ſome ſlight errors in the *non-naturals*, do go off without that regular ſtruggle and violent evacuation he reckons neceſſary to conſtitute a *criſis*. But, with *Galen*'s leave, later times have made it ſufficiently evident that there may be *Ephemeras* intirely independent on the common errors of the *non-naturals*, and truly of the epidemic kind; and requiring the ſame careful management to carry off the morbid matter by a *criſis*, as in other more laſting fevers. Thus, beſide others, the great and famous *ſweating ſickneſs* [a] *ann.* 1485, 1506, 1517, 1528, 1551 [b], almoſt peculiar to *Engliſhmen*, infeſting *Germany* and ſome other parts only *ann.* 1529 [c], proved at firſt fatal ſuddenly, or in a few hours [d]; and afterwards when underſtood was eaſily managed, and for the moſt part cured in a day [e].

C. That *phrenitical fever*, an endemial *Egyptian* diſeaſe, called by them *Demelmuia*, which comes in annually with the irregular

[a] Caius de Ephem. Britan. Fracaſtor. de Morb. Contag. II, 5. Cambden. Britan. p. 451. Bacon. Hiſt. K. Henr. VII. p. 9.
[b] Caius Ibid. p. 19. 20.
[c] Ibid. p. 22. 66.
[d] Ibid. p. 9. 10. 27.
[e] Ibid. p. 10. 110. 111.

heats

heats of their firſt ſummer in *March*, *April* and *May*, kills ordinarily in a few hours [a]. ESSAY I.

D. *Squinances*, diſcovering nothing wrong in the *fauces* or neck, kill ſuddenly, it may be the very firſt day. Sometimes death is delayed till the 2, 3 or 4 [b]. In another kind they are ſaid not to die till the 5, 7 or 9 [c].

E. In an univerſal *inflammation* of the lungs and heart the patient loſes his ſtrength, turns cold and ſenſeleſs, and dies on the 2 or 3 day [d].

F. In *Edinburgh ann.* 1732 there was an epidemical ſhort *fever*, that went off in 2 or 3 days, leaving behind it however a cough, *&c* [e].

G. And at *Utrecht March* 1729 there was an eaſy *pleuriſy* going off on the 3 day [f].

H. And *Sennertus* gives us an account of a benign *catarrhous fever ann.* 1580. very

[a] Alpin. Med. Aegypt. I, 13. p. 50. I, 14. p. 53. 54. Med. Method. II, 4. p. 101.
[b] Præn. XXIII, 5. Coac. III, 96. I. Prædict. XI, 4.
[c] III. De Morb. X, 14.
[d] Coac. III, 185.
[e] Med. Eſſ. II. p. 29. 30.
[f] Muſchenbr. in Phil. Tranſ. 425. p. 368.

epidemical

ESSAY I. epidemical and far ſpread, wherein ſome had a ſweat, and recovered the 3 or 4 day [a].

K. After a debauch an obmuteſcence without a *fever* kills on the 3 day [b].

L. Violent *auricular inflammations* kill for the moſt part on the 3 day [c]. In ſummer they make an eruption on the 5 day or later [d].

M. Thoſe who are ſtruck (βληθοι) die on the 3 or 5 day, not arriving at the 7 [e].

N. The *Siriaſis*, under which *Mercurialis* [f] comprehends the καυμα κεφαλης of *Alexander Aphrodiſæus* [g], the *Morbus ſolſtitialis* in *Plautus* [h], and the σφακελισμος εγκεφαλου of *Hippocrates*, kills commonly in three days; ſome eſcape to the 5, ſome to the 7, and ſome recover [i]. And ſo too we are told that *Phrenſies* kill on the 3,

[a] De Febr. IV, 17. p. 842.
[b] II. De Morb. XXII, 4.
[c] VI. Epid. VI, 28.
[d] Ibid. 43.
[e] III. De Morb. III, 9.
[f] Var. Lect. V, 3.
[g] Probl. 98.
[h] Trinum. II, 4.
[i] Aph. VII, 5. Coac. II, 53. II. De Morb. V, 21. XX, 8.

5 or

5 or 7 [a]. But ſometimes the *criſis* of this diſeaſe is ſpun out to the 11 [b].

O. The Συνοχος or *continent fever*, if there be no error of management, is according to *Galen* judged on the 4th. But ſuch a *fever* and *criſis* ſeldom happen. *Archigenes* in all his life-time ſaw it only twice, and *Galen* but once. But the *continued* very acute *fevers*, he ſays, were rather judged commonly on the 3 or 5, ſcarce ever on the 4 [c]. Yet *Pericles* a patient of *Hippocrates* in *Abdera* was freed from ſuch a fever on the 4 day by a hot ſweat over all his body *.

P. If in the very beginning of a pleuriſy there appears ſpitting of various hues (παμποικιλαι πτυσιες,) they often die on the 3 or 5 day [d]. The acceſſions of this diſeaſe happening commonly on the 3, 5, 7, *&c.* days [e].

Q. A *fever* going off by a ſweat, and the urine being red with a white ſediment,

[a] III. De Morb. IX, 13.
[b] De Affect. X, 18.
[c] De Criſ. III, 4. * III. Epid. III. Aegr. 6.
[d] Coac. III, 123. III. De Morb. XXI, 22. Boerh. Aph. §. 901.
[e] Galen. Com. in Aph. I, 12. De Criſ. I, 7.

there

ESSAY I.

there is a relapſe that ſame day; which is judged without danger on the 5[a]. I have alſo often found relapſe fevers end by a criſis on the 5 day.

R. Winter *coughs* ſometimes have a fever going off eaſily on the 5th day: But the *coughs* continue about 40 [b].

S. In *January* 1729 there appeared at *Utrecht* an epidemic *anginous* fever, which in ſome went off on the 5 day. But even ſome of theſe relapſed about the 7, and were not finally cured before the 14 [c].

T. At *Edinburgh ann.* 1731 there was a *fever* beginning with a *diarrhœa*, wherein by good management the patients were got well on the 5 or 6 day. But if not right taken care of they died on the 10 or 12 [d].

21. A. There are on the other hand remarkably long fevers and late criſes obſerved. See §. 16. LL. §. 17. F. H. N.

B. In the firſt *Thaſian conſtitution* deſcribed by *Hippocrates* moſt of the ſummer and

[a] De Criſ. I, 10. X, 9.
[b] VII. Epid. XXXI, 2.
[c] See §. 16. HH.
[d] Med. Eſſ. I. p. 41.

autumn fevers laſted about 40 days, many of them about 80, ſome few only 20, as was formerly taken notice of; §. 17. E. ESSAY I.

C. The autumnal *continual fevers* of the ſecond *conſtitution* were likewiſe very tedious and irregular, ſeldom a formal *criſis*. Some few had ſomething like one about the 80 day. And even theſe were ſubject to relapſes, ſo as to labour under ſickneſs all the ſucceeding winter [a].

D. And in that irregular and malignant *conſtitution*, which commonly carries the title of κάλασασις λοιμώδης, ſome were *judged* too about the 80 day. And even in theſe late criſes many died [b].

E. In the third *Thaſian conſtitution* ſome of the winter *phrenitical* fevers had a new rigor on the 20, and got not their final criſis before the 40 day [c].

F. Such *fevers*, in their duration at leaſt, agree with the *Quotidiana continua periodica* Barbaris *Latica* of *Bellini*, of which he ſays "in longum protrahitur, vix deſinit ante "diem 40, & ad 60 atque ulterius excur-"rit [d]." And ſo too of the *Quartana continua periodica* he ſays "protrahitur

[a] I. Epid. II, 55. [b] III. Epid. III, 114.
[c] I. Epid. II, 206. [d] De Febr. p. 258.

ESSAY I. " ad 40 diem & ulterius [a]." And the very ſame thing he affirms of the *Febris lenta* [b].

G. Thoſe in whom a *pleuriſy* or *peripneumony* lands in an *empyema* are cleanſed by expectoration within 40 *days*. If not they fall into a Phthiſis [c].

H. Soft and indolent tumors in the hypochonders, continuing with a fever above 60 days, ſignify a ſuppuration [d].

I. The *pituita alba* (λευκον φλεγμα) is *judged* of in 30 days, whether it be deadly or no [e].

22. There were ſome *days*, on which *criſes* falling, ſeldom proved beneficial; eſpecially the 6. Nor are the 80, 10 or 12 very lucky.

A. *Galen* expected no good on the 6th *day* [f]. And accordingly he obſerved a conſtitution of autumnal *fevers*, all which had their *criſes* thereon: but the *criſes* were not good [g]. See too §. 39. N. O. P. Q.

[a] Ibid. p. 259. [b] Ibid. p. 264. [c] Aph. V, 15. Coac. III, 142. II. De Morb. LV, 23. LXII, 11. III. De Morb. XVI, 35. Celſ. Medic. II, 7. p. 62, 16. II, 8. p. 67, 2. Aret. de Acut. Cauſ. &c. II, 1. [d] Præn. VI, 10. Coac. II, 233. [e] De Int. Affect. XXIII, 28. [f] De Dieb. Decr. I, 2. [g] Ibid. II, 7.

B. He lays it down too as a general rule that thoſe, who ſuffer a remarkable change to the worſe on the 4, do commonly die on the 6 [a]. Agreeable to this we find that in the third *conſtitution* in *Thaſus Hippocrates* tells us there was a bad *ardent fever* in autumn and winter, wherein bad and ſevere ſymptoms appeared on the 4, and death on the 6 [b].

C. However in another place of the *Epidemics*, aſcribed to *Hippocrates*, mention is made of a certain ſpring ſeaſon, wherein the *criſes* happened on the 6 and 8, but with what ſucceſs we are not told [c].

D. At *Edinburgh* in autumn *ann.* 1732 there was a *fever* which commonly proved mortal the 8 or 9 day [d].

E. At *Utrecht* in *May* 1729 a *ſcarlet fever* akin, I think, to the *Morbillaris*, ſhewed the eruption on the 3 or 4. In ſome a *delirium* and other bad ſymptoms on the 5, who died the 8 day. But moſt of thoſe who had not theſe bad ſymptoms eſcaped on the 10 [e].

[a] Ibid. I, 4. [b] I. Epid. II, 158—162.
[c] IV. Epid. III, 22. [d] Med. Eſſ. II, p. 27.
[e] Muſchenbr. in Phil. Tranſ. 425. p. 373. 374.

ESSAY I.

F. Criſes on the 12 day are certainly very rare; ſo rare that *Galen* in all his life never obſerved ſuch a thing [a]. He allows they may poſſibly have happened; but then they were imperfect, obſcure, without ſigns, but not without a great deal of danger. How ſurpriſingly agreeable to this are our lateſt obſervations? In *Edinburgh ann.* 1731 a fever appeared beginning with a *diarrhœa*, which if neglected in the beginning continued obſtinate in its bad ſymptoms till it killed on the 10 or 12 day: as we formerly took notice of on another occaſion [b]. As we did too of the epidemic *bilious fever* at *Piſa ann.* 1661, in which ſome died on the 10 or 12 [c].

G. And at *York ann.* 1728 there aroſe a *putrid* epidemic *fever*, wherein upon the 12 day a *delirium* and other forerunners of death came on [d].

H. And ſo likewiſe in the *putrid fever ann.* 1719 on the 12 day there came on a *diarrhœa*, which intirely weakened the patient [e]. But when the ſame fever had been all along from the beginning accompanied with an open belly it uſed to go off

[a] De Dieb. Decr. I, 2. [b] §. 20. T. [c] §. 16. T.
[d] Winteringh. Com. Noſol. p. 122. [e] Ibid. p. 42.

by a ſweat about the 16 [a]. Which however we may preſume ſeldom happens: ſeeing *Galen* in his long and very extenſive practice never had occaſion to obſerve a criſis on this day [b]. ESSAY I.

I. And we found this 12 day only on two different occaſions decretory in pectoral caſes, and that was by death, or at beſt a ſuppuration. §. 15. V. QQ.

K. However I find an inſtance of the 12 day carrying off a diſeaſe in a ſalutary way. A *Hickup* coming on at the end of a *continued fever* requires juſt that time to perform its courſe. This *Tulpius* [c] aſſures us; and cites *Marcus Gattinaria* and *Hercules* of *Saxony* as having before him obſerved the ſame thing. And Dr. *Freind* [d] tells us of a patient of his that kept the *ſingultus* full out 11 days. But this ſeems to have been in the fever itſelf.

23. From theſe obſervations collated together does it not appear that in various times and places nature has appeared obſequious, as it were, to *Hippocrates*'s rules? or rather, which would ſeem to be the truth

[a] Ibid. p. 43. [b] De Dieb. Decr. I, 2.
[c] Obſ. Med. IV, 24. [d] Epiſt. de Purg. p. 145.

ESSAY I.

of the matter, that this great man has by his diligent and careful reſearches penetrated into the true ſtate of nature, and perceived the real courſes and periods of diſeaſes, as they readily flow from the mechaniſm of the human body diſturbed in ſuch and ſuch ways?

24. But farther to illuſtrate the *Hippocratical* doctrine of *fevers* and their *criſes*, and to ſhew the uniformity of nature in different countries, it will be worth while to obſerve and compare the appearances of *Intermittent fevers* in various climes and ages.

We might obſerve how regularly every ſpecies of *Agues* have their proper and ſpecific times for the regular returns of the paroxyſms, a *Quotidian* in 24 hours, a *Tertian* in about 48, a *Quartan* in about 72 hours, and ſo on of others. But this is obvious and every body has already remarked it. We chuſe rather at this time to take a more particular notice of a beautiful regularity in the intire duration of the diſeaſes themſelves, ſomewhat analogous to the duration of *continual fevers* already treated of.

25. Every

25. Every body is appriſed of *Hippocrates*'s obſervation of an *exquiſite Tertian* ending commonly in 7 paroxyſms, ſometimes ſooner [a]. And *Galen* tells us that we are to regard the paroxyſms of *Intermittent fevers* as we do the days of *continued* ones [b]. So that they may be thought to have ſome affinity with that numerous claſs of *fevers* already rehearſed §. 15.

A. This was the duration of the autumnal and winter Agues of the ſecond *Thaſian* conſtitution [c]. And in *Perinthus* there appeared ſuch an *Intermittent* which laſted preciſely that number of fits [d].

B. And at *Utrecht* Dr. *Muſchenbroek* found the *Tertain agues* ann. 1729 both vernal and autumnal, ſeldom to continue beyond the 6 or 7 fit [e]. The vernal ones *ann.* 1728 ſeldom had more than 8 [f].

C. The *Tertians* in the *Lower Hungary* in ſummer 1711 laſted but 5 or 6, or at moſt 7 paroxyſms [g].

[a] Aph. IV, 59. De Jud. IV, 10. Coac. I, 212. I. Epid. II, 33. [b] Com. in Hip. Progn. III, 7. [c] I. Epid. II, 33. [d] II. Epid. III, 82. [e] Phil. Tranſ. 425. p. 371. 375. 377. [f] Ephem. Ultraj. 1728. p. 682. [g] Genſel. Conſt. Epid. Hung. 1711. p. 798.

ESSAY I.

D. *Galen*[a], and after him *Bellini*[b], and others, pretend to a more ſubtil obſervation in this matter. They ſay that if, with other laudable ſymptoms, on the firſt day there appear a light and equal ſediment in the urine the *fever* will not continue beyond the 3 paroxyſm. If on the firſt day the urine have no ſediment, but only a white cloud, we may expect a 4th fit. But if the urine be high coloured without any thing of a cloud or ſuſpenſion in it, it will be carried on to the 7th paroxyſm.

26. But we ſhall find ſtill a greater and more ſurpriſing uniformity in the hiſtory of *Quartans*, both with reſpect to their ſeaſon of appearing and their regular duration.

A. *Hippocrates* obſerved *Quartans* to be almoſt peculiar to autumn, ſometimes however appearing in ſummer[c].

B. *Celſus* either obſerved the ſame thing, or copied it from *Hippocrates*[d].

C. But *Pereira*, who valued himſelf upon correcting the ancients, will not be ſuſpected of copying from any body, eſpecially in this

[a] De Crif. II, 3. [b] De Febr. p. 267. 426.
[c] Aph. II, 25. III, 21. 23. De Nat. Hum. XXIX, 2. [d] Medic. II, 1. p. 44, 15.

particular.

particular. And from his own moſt correct obſervations he found, that people, who had never felt the ſeverity of a *Quartan*, were liable to be attacked by it only in the end of ſummer, and firſt part of autumn: that is to ſay, chiefly in the laſt days of *July*, in *Auguſt* and *September*, ſeldom in the beginning of *July*, or in the month of *October*; never in *December*, or any ſubſequent time from thence to the end of *June* [a].

D. And exactly conform hereto Dr. *Sydenham* pronounces *Quartan agues* to be the true and legitimate offspring of autumn [b], coming in commonly in *Auguſt* and the beginning of *September*, ſeldom in the ſucceeding months, and in the laſt days of *June*, and in the month of *July* only when they are uncommonly epidemic [c]. And accordingly he remarks it as ſingular and extraordinary, when *ann.* 1661 they began ſo early as *St. John's day* [d], which is the 24 of *June*. By this early appearance he found a more than ordinary diſpoſition of the ſeaſon to *Quartans*, which this year became ſo very frequent. And *Sennertus* obſerved them

[a] Nov. Medic. 35. p. 537. 54. p. 717. 721. 58. p. 757. [b] Oper. p. 24. 87. [c] Ibid. p. 86. [d] Ibid. p. 82.

commonly

ESSAY I. commonly to come in about the autumnal Equinox; ſcarce ever having ſeen one begin after the Winter Solſtice [a].

E. So much for the ſeaſon of *Quartans*. As to their duration *Hippocrates* ſays in general that of all the *Ague* kind they are the longeſt, and at the ſame time the leaſt dangerous [b]. Seldom however they laſt above a year [c].

F. *Celſus* inſinuates that *Quartans* do frequently laſt long, and continue during the winter; ſeldom going off before the ſpring [d].

G. And ſo *Sydenham* obſerves, that though now and then this diſeaſe may go off about the winter ſolſtice, yet commonly it laſts till the ſpring æquinox; nay ſometimes continues the whole year round, when the patient is old, or has been brought low by unſeaſonable evacuations [e].

H. And *Pereira* ſays in general that they ſeldom go off before the end of winter or beginning of the ſpring [f]. Some few may have been obſerved to have had conſiderable

[a] De Febr. II, 17. [b] I. Epid. III, 17. De Nat. Hum. XXVIII, 3—9. [c] VI. Epid. VI, 42.
[d] Medic. II, 1. p. 44, 15. III, 15. p. 144, 24. III, 16. p. 147, 8. [e] Oper. p. 85. 92.
[f] Nov. Med. 54. p. 713, 727. 58. p. 758. 759. 768.

intermiſſions

intermiſſions about the ſolſtice, but not to be intirely free before the warmer ſeaſon [a]. By good management they are commonly got off about the end of *April* or beginning of *May* [b]. He never obſerved any to have laſted till the end of *May*, except in thoſe who laboured under hypochondriac obſtructions of the liver or ſpleen [c]. However he hints (which afterwards in the next century *Sydenham* obſerved more explicitly) that ſome by an improper management ſuffered above a year [d]. And *ann.* 1545, 1546 there raged through all *Spain* a peſtilential kind of *Quartans* that frequently killed the patients after a continuance of 10 or 12 months, ſometimes ſooner, ſometimes later [e].

I. Mr. *de Baillou* had a deeply impreſſed notion of the obſtinacy and anomalous nature of autumnal diſeaſes [f]. In particular he tells us of thoſe who were ſeized with the epidemic *Quartans ann.* 1571, that they who were managed by the common rules of evacuations, *&c.* almoſt all died, while thoſe who were left to their own natural courſe gradually wore out

[a] Ibid. 54. p. 712. 713. [b] Ibid. 58. p. 767.
[c] Ibid. 54. p. 729. [d] Ibid. 58. p. 767.
[e] Ibid. 54. p. 720. [f] Epid. II, p. 176. 180.

of

ESSAY I. of their trouble againſt the next month of *March* [a].

K. But this long duration of *Quartans* is ſolely to be underſtood of the firſt time one is ſeized with this diſeaſe. Any time after in all his life it eaſily ſpends itſelf in a few fits; which *Sydenham* juſtly thought to be of great conſequence to be duly appriſed of [b].

L. And *Pereira* had laboriouſly ſettled this point in his diſputes againſt the ancients; and determines the number of paroxyſms to be commonly 4, ſometimes 7, ſeldom to come up to 11 [c].

M. In this particular concerning the true genius and *periods* of *Quartans Pereira* and *Sydenham* ſeem to have outdone the ancients themſelves. And I ſuppoſe it was this laſt circumſtance of the duration of theſe *Agues* not well attended to that gave occaſion to *Celſus* to ſay, that *Quartans* continue very long if they do not happen to be diſcuſſed in the beginning [d]. And ſo *Hippocrates*, though in general he affirms *Quartans* to be

[a] Ibid. I. p. 27. II, p. 182. [b] Oper. p. 85.
[c] Nov. Med. 54. p. 712. 716. 58. p. 760.
[d] Medic. III, 15. p. 144, 24.

of

of a long duration [a]; yet at the ſame time he aſſures us that they are very ſhort, if they happen in perſons and ſeaſons not favorable to that diſeaſe [b].

Tell me now who would have expected that the diſeaſes of *Greece*, *Italy* and *Spain* would have been ſo much in concert with thoſe of *England*?

It may be thought odd and ſuperfluous to have ſo carefully conſidered the extraordinary, and commonly unheeded circumſtances of a diſeaſe that ſeldom appears in this country. In *Scotland* one ſhall ſcarcely meet with a *Quartan Ague* twice in a lifetime; which is ſometimes ſo frequent among our neareſt neighbours. But theſe obſervations may ſtill be uſeful both with regard to other nations and other diſtempers: and are at leaſt of ſervice in the view they ſtand here, in confirming the regularity and uniformity of diſeaſes in ſome other very far diſtant countries.

27. To illuſtrate which ſtill farther it may be convenient to take a particular ſur-

[a] De Nat. Hum. XXVIII, 3—9. I. Epid. III, 17. De Affect. XIX, 6. [b] De Nat. Hum. XXIX, 6. 7. De Affect. Ibid.

vey

ESSAY I.

vey of ſome other *fevers*, thoſe eſpecially of the *efflorescent* kind, which run their ſeveral *ſtadia* or *courſes* in determined *periods* of time, much the ſame in all countries, where they have been carefully obſerved, and accurately deſcribed.

The moſt remarkable, and what moſt frequently occurs of this kind, is the *Small Pox*; a terrible diſeaſe, and which as the *Arabians* had the mortification firſt to ſuffer, at leaſt before the *Greeks*, ſo they have the honour of firſt deſcribing it, and laying down rules for its management. To me they ſeem to make but a ſorry compliment to *Hippocrates*, *Celſus*, *Pliny* and *Galen*, and his followers, who out of a miſtaken fondneſs for their glory will ſtill contend that diſeaſe to have ſubſiſted in ancient times. If theſe great authors, and *Aretæus* and *Cælius Aurelianus*, &c. ſaw the *Small Pox* as the *Arabians* ſaw them in their day, and as we ſee them now, ſurely they have been very bad hiſtorians of diſeaſes, who have painted the *variolous fever* and *variolæ* ſo wretchedly ill, that we are at a loſs, without overſtraining a few ſhort ſcrapes of ſome of theſe writers, to find ſo much as any tolerable reſemblance of them in all their

their works: while their delineations of other much leſs notable diſeaſes, they were acquainted with, are ſo full, ſo lively and juſt, and ſtill ſo agreeable to their preſent phænomena, that the moderns in this particular have certainly not outdone them, nay rarely equalled them. Yea this diſeaſe is with ſo little reaſon to be expected in the ancient medical writers, that the learned Dr. *Freind* could find nothing of it among the very lateſt of the *Greek* Phyſicians and Hiſtorians[a]: as if it had never invaded the *Grecian* empire, and had been confined for many ages to the *Mahometan* dominions; and propagated only to thoſe countries, which had ſome remarkable connexion with them.

The origin of this malady is not certainly known: the firſt writers thereof do not ſpeak of it as perfectly new, or unheard of in the world before. However, by the moſt early notices we have of it, we firſt find it in *Egypt* about the middle of the 7th century, probably brought thither by the *Saracens* from *Arabia*, along with their new-faſhioned warlike religion: both which evils, flying like lightening, they propagated

[a] Hiſt. Phyſ. I. p. 74.

through

ESSAY I. through a great part of the world in a very little time. And now, though their religion has been long at a ſtand, there is ſcarce a corner in the habitable world, that is not often viſited with that other terrible and monſtrous diſtemper.

The *Arabian* authors give a pretty good account of this diſeaſe, deſcribing its appearances, and the ſeveral methods they had found moſt ſucceſsful in curing it. But as they do not ſeem to have had ſuch a ſpirit of elegance and correctneſs, nor the regular and methodical inſtitutions of the *Greeks*, they did not handle it in ſuch a complete manner as were to be wiſhed. Nay, what is more ſurpriſing, the reſtorers of the *Greek* Medicine in the 16th century, who in other things were ſo diligent and careful, did not act up to this character in treating of the *Small Pox* and *Meaſles*; of which any one may be eaſily convinced by but looking into the ſuperficial and confuſed accounts of theſe *Exanthemata*, given us by *Fernel* and *Lommius*, who treated the *Greek* maladies in another faſhion. So that the honour of perfecting the hiſtory of the *Small Pox* is owing to the later moderns, and eſpecially to the great *Sydenham*, who by himſelf has perhaps

perhaps done more that way than all the reſt of the world put together had done for a thouſand years before him; eſpecially in determining its ſeveral *Stages*, which we are moſt concerned with; as ſerving for a beautiful illuſtration of the natural and regular *periods* of diſeaſes. And we can with the greater aſſurance confide in *Sydenham*'s obſervations, that they have been verified and approved of by the beſt practitioners both in *Britain* and foreign parts.

The *Arabians* not only obſerved ſeveral varieties of the *Small Pox* as to their *number*, *ſize*, *conſiſtence*, *colour*, *&c.* but in their works we may in ſome meaſure trace them as diſtinguiſhed into the two cardinal kinds of the *Diſtinct* and *Confluent:* which *Sydenham* and the later writers chiefly inſiſt on, and which muſt be carefully kept in view in reckoning up and determining the *Stadia* of this diſeaſe.

28. Firſt then of the *Diſtinct* ſort we are to obſerve that they are the eaſieſt, moſt ſimple, moſt regular, and attended with the leaſt danger; but even theſe are not in all conſtitutions of the diſeaſe, and in all perſons perfectly uniform.

ESSAY I.

A. The *Small Pox* of *London ann.* 1667, 1668, 1669 were the moſt regular and genuine ever *Sydenham* had occaſion to obſerve. And the *Diſtinct* kind uſed not to ſhew themſelves before the 4 day [a], ſometimes later [b]. Not as if this in all conſtitutions did exactly hold. In the anomalous *Small Pox* of 1670, 1671, 1672, which were of a leſs benign nature than the former, the eruption even of this kind fell out commonly on the 3 day [c].

So that it ſeems to have been chiefly the eruption of the *Diſtinct* kind *Avicenna* [d] pointed at, when he ſays, that the beginning of their coming out is after the 2 day, *viz.* on the 3 and following one. And it muſt be of the ſame we are to underſtand *Fracaſtorio* and *Hor. Augenio*, when they ſay that the pox uſe to appear on the 4 day [e]. And ſo I ſuppoſe were thoſe, whereof *Fernel* ſays, that they appear the 3 or 4, ſometimes on the 5 day [f]. And *Lommius* [g] co-

[a] Oper. p. 133. 135. 143. 148. 150. 201. 589.
[b] Ibid. p. 135. [c] Ibid. p. 201.
[d] Can. IV, 1. IV, 6. p. 72. [e] Fracaſtor. de Morb. Contag. II, 2. p. 140. Augen. de Febr. X, 4. p. 414. Vid. & Sennert. de Febr. IV, 12. p. 833. Willis de Febr. 15. p. 257. 260. 262. Sylv. Prax. Med. Append. I, 9. p. 617. [f] Patholog. IV, 18. De Abd. Rer. Cauſ. II, 12. p. 509. [g] Obſ. Med. II, p. 103.

pies this near word for word, as an infinite number of other things, from *Fernel.*

B. The *Eruption* continues 2 or 3 days, ſo that it uſeth to be complete about the 6 [a], *Fonſeca* reckons the *eruption* from the 4 to the 7 [b].

C. From the firſt of the eruption the puſtules are conſtantly riſing, and filling more and more with a purulent *ſerum* until the 8 day, that, by *Sydenham*'s account [c], thoſe of the genuine ſort begin to ripen, their intervals appear reddened, the face ſwells *&c.*

D. It is on this 8 day that thoſe who labour under this kind of *Pox* are in the greateſt danger of dying; the forementioned ſalutary ſigns of *maturation* not coming well on, but the perſon turning feveriſh, reſtleſs, delirious, *&c* [d].

E. On the 11 day from the beginning in the abovementioned genuine *diſtinct* kind the ſwelling and inflammation of the face abates, the puſtules being now at their greateſt height, and fully ripe begin to dry *&c* [e]. Whence *Sennertus* [f] with ſome others

[a] Vid. Morton. Pyretolog. II, 6. p. 59. II, 8. p. 104. [b] Meth. Cur. Febr. 54. p. 423. 431. [c] Oper. p. 133. 134. 157. 546. 590. [d] Ibid. p. 104. 139. 546. 590. [e] Ibid. p. 134. 590. [f] De Febr. IV, 12. p. 833.

ESSAY I. had very good reaſon to ſay that the diſeaſe was now (on the 11 day) in its *Status* or *Height*.

F. They uſed to ſay that from the 11 to the 14 the diſeaſe was in its *declination* [a]. And accordingly by *Sydenham*'s obſervations on the 14 or 15 the puſtules are gone. Only thoſe of the hands laſt a day or two longer than the reſt [b].

29. From this ſpecies of the *Small Pox* the *confluent* kind differs ſo much, that they conſtitute, as it were, another ſort of diſeaſe, the *ſtages* whereof vary exceeding widely from the hitherto deſcribed *periods* of the benign diſtinct kind.

A. In the moſt perfect and regular of this *confluent* ſort, ſuch as was the *conſtitution* of *ann.* 1667, 1668, 1669 deſcribed by *Sydenham*, the *eruption* happened for the moſt part on the 3 day, ſometimes ſooner, ſeldom later [c].

B. When this happened before the 3 day it was a ſign of the greater virulence of the *Pox* [d]. So that *Aaron*, *Iſaac* and *Rhaſes*, though they ſay in general that the *Small*

[a] Vid. Sennert. Ibid. [b] Oper. p. 134. 590.
[c] Ibid. p. 135. 381. 591. [d] Ibid. p. 136.

Pox

Pox appear commonly on the 3 day, yet theſe firſt writers on this diſeaſe do very well obſerve, that it is poſſible they may come out even on the 1 and 2 day, from the violence of the fever, and impetuouſneſs of the humours [a].

Accordingly the *London conſtitution ann.* 1670, 1671, 1672 was certainly more virulent than the preceding one, in conſequence of which they began to ſhew themſelves ſometimes on the 2, ſometimes on the 3 [b]. And at *Plymouth ann.* 1724, 1725 in a very anomalous kind they ſometimes appeared in leſs than 24 hours from the firſt attack [c].

But on the other hand it may ſometimes happen that even this *confluent* kind may paſs the 3 day before their appearance [d]. Yea now and then by reaſon of ſome extraordinary inflammatory ſtate of the loins, the ſide, the ſtomach, *&c.* the patient may be ſo univerſally conſtricted that the *Pox*, though of a *confluent* and malignant ſort, ſhall not appear before the 5 day [e].

[a] Vid. Rhaſ. Cont. XXX, XIII, 1. De Peſt. 15. Iſaac. de Febr. V, 5. [b] Sydenh. Ibid. p. 202.
[c] Huxham in Phil. Tranſ. Abr. VI, 3. p. 140.
[d] Sydenh. Ibid. p. 381. [e] Ibid. p. 135. 136. 591.

ESSAY I.

C. From all which, together with what we have advanced formerly concerning the appearance of the *distinct* kind, it is plain that the 3 day is the most general term of the *eruption*, and as it were a *medium* in the several species of the *Small Pox*. Which accordingly is the day pitched upon by the *Arabian* authors, as we just now observed, and by *Pereira*[a]; who has been at more pains in surveying and describing this disease than the rest of his contemporaries. However, if other circumstances be favourable, we should be better pleased with a kindly delay till the 4: and the more it anticipate the 3 we are to be the more upon our guard, and to lay our account with the greater violence and malignity of the disease. Which is directly contrary to the very erroneous prognostick of some authors, otherwise of good note and credit, who affirm that the sooner the *Pox* appear it is the better and safer for the patient[b]. Whereas in the *confluent* and virulent cases the *eruption* comes sooner on, though indeed the suc-

[a] Nov. Med. 69. p. 904. 905.

[b] Gordon. Lil. Medic. I, 12. Holler. de Morb. Intern. II. p. 574. Lom. Obs. Medic. II, p. 103. Augen. de Febr. IX, 20. Sennert. de Febr. IV, 12. p. 833.

ceeding

ceeding maturation takes up more time, than in the eaſier and more benign kind. ESSAY I.

D. On the day of the *eruption*, ſometimes a day or two later, the *Salivation* in adults begins to riſe[a]. But the *Diarrhœa* in infants, analogous thereto, does not come on ſo ſoon, and ſometimes not at all[b].

E. On the 6 day of the diſeaſe, that is the 4 of the *eruption*, the puſtules are all out and fully in view[c]; and the whole body much inflamed[d].

F. the confluent pox uſe to raiſe the face into an unequal ſort of pellicle, which after the 8 day grows rough, and ſwells higher, *&c*[e].

G. On the 11 day the ſwelling of the face, and the ſalivation begin to abate, though not going intirely off for a day or two[f].

H. On this 11 day by the reſorption into the blood of the variolous *pus*, which is often in too great a quantity to be thrown off by the ſkin, a commotion ariſes called the *ſecondary fever*, a new production, and

[a] Sydenh. Ibid. p. 138. 154. 592. [b] Ibid. p. 138. 592. [c] Ibid. p. 237. 357. 370. 548. 593.
[d] Ibid. p. 374. [e] Ibid. p. 136. 376. 378. 591.
[f] Ibid. p. 138. 140. 154. 155. 159. 238. 376. 592.

ESSAY I.

diſtinct from what appeared at the commencement of the diſeaſe: which, though flowing from the nature of the malady itſelf, and obvious in all ages ſince its firſt riſe, had been taken notice of only by two or three authors [a], and little minded, before *Sydenham* ſo carefully inculcated it upon us [b].

I. And on this day too in the moſt regular *confluent* kind, ſuch as we have been already told was that of *London ann.* 1667, 1668, 1669, the patient is in the greateſt danger of falling into reſtleſſneſs, ſuffocation, ſtupor, and other bad ſymptoms, quickly ending in death [c].

The more benign the pox are they ripen and bring on other analogous ſymptoms the ſooner [d]. Thus in the milder *conſtitution ann.* 1667 *&c.* we juſt now found that the *ſecondary fever*, and great danger was on the 11 day. But in that anomalous ſort *ann.* 1670, 1671, 1672 they did not

[a] Diom. Amic. apud Freind Epiſt. de Purg. &c. p. 121. 137. Augen. de Febr. IX, 17. 19. Zacut. Luſit. Med. Princ. Hiſt. IV, 55. p. 786. Mayern. Prax. p. 444. [b] Oper. p. 355. 377. 381. 546. 547. 548. 549. 594. [c] Ibid. p. 140. 141. 160. 203. 234. 357. 364. 375. 377. 381. 546. 548. 590. 592.
[d] Ibid. p. 234.

ripen

ripen ſo faſt, they did not arrive at this dangerous period before the 14, and ſometimes the 17 day in the more crude caſes [a]. Yea in that very malignant and moſt crude kind of *ann.* 1674, 1675 more died about the 20 or 21 [b].

K. Not but that theſe diſeaſes may be ſo very virulent and inflammatory as to kill much ſooner, and before this ſtage of the *ſecondary fever*, any violent or croſs ſymptom coming unluckily in the way, as phrenzy, purple ſpots, hæmoptoe, anomalous diarrhœa, *&c* [c].

Dr. *Morton* might furniſh us with plenty of examples of people in the *Small Pox* dying before their time. But his patients underwent ſuch a fiery trial between an ardent diſeaſe and inflammatory medicines, that, as was finely ſaid by Dr. *Mead* [d], thoſe of them who ſurvived ſeem to have eſcaped ὡς διὰ πυρος.

We have no reaſon to paſs any ſuch cenſure on the ſober and regular practice of the very judicious Dr. *Huxham*. Yet in the

[a] Ibid. p. 203. 234. 355. 546. 547. 548. 592.
[b] Ibid. p. 234. 546. 592. [c] Ibid. p. 141. 142. 160. 355. 592. [d] Apud Freind Com. de Febr. 7. p. 101.

anomalous

ESSAY I. anomalous *Small Pox* at *Plymouth* ann. 1724, 1725, treated by him, ſome died the 5 or 6 day, others dwined till the 10 or 11 [a].

But the moſt diligent and ingenious Dr. *Muſchenbroek* had the misfortune to be engaged in the management of a ſtill more anomalous ſort, even worſe perhaps than *Sydenham*'s worſt kind of *Variolæ Nigræ ann.* 1674, 1675, 1681 [b]. At *Utrecht* ann. 1729. in the beginning of autumn the *Small Pox* grew more than ordinary *confluent* and deadly, and carried off many about the 8 or 9 day [c]. But ſome time after, towards the end of that ſeaſon, they grew ſo very malignant and, as it were, peſtilential, that they killed ſome on the 5 or 6 day, others on the 8, 11, 14, 16; yea ſome after a month's torment; all the moſt plauſible and reaſonably contrived methods of different kinds proving all equally unſucceſsful in this moſt terrible and painful diſeaſe [d].

30. The other ſpecieſes of the *Small Pox*, as the *coherent*, or thoſe of any other name, are all, as it were, in a middle between

[a] Phil. Tranſ. Abr. VI, 3. p. 140. [b] Oper. p. 233. &c. 354. &c. [c] Phil. Tranſ. 425. p. 376. [d] Ibid. p. 381.

thoſe

thoſe of the *diſtinct* and *confluent* kinds, or ſome way reducible to them: and their periods, from what we have already adduced, are accordingly to be judged of.

31. But not only the natural diſeaſes have their ſettled periods. Even thoſe that are procured by art obſerve rules very much like the others, though perhaps not altogether ſo regular. Some people obſerving the miſerable havock made by the *Small Pox*, and ingeniouſly ſtudious of the preſervation of good looks, and of a better chance of life, bethought themſelves how they might avoid the bad conſequences of this dreadful evil. And as all mankind ſeem to be naturally liable to it, no antidote having been yet found out able to preſerve us from the attack, they concluded that what they could not avoid having ſome time or other, they would voluntarily undergo, and take the *Pox* in their own way, and when they were in the fitteſt ſtate to get the better of them.

In *China* they are ſaid to have had a way time out of mind of infecting their children with the *Small Pox*, by putting up the perſon's noſe a cotton tent dipped in the variolous

ESSAY I. variolous matter, gathered from the puſtules of ſome body labouring under that diſeaſe [a].

In *South Wales* very anciently they have had a way of infecting themſelves by applying the variolous matter to their ſkins, ſometimes pricked or ſcratched, ſo as that its contagious quality may enter into the blood [b]. But however old this uſage may have been in ſome places in *Wales*, it has always been very confined, never ſpreading far, nor, not ſo much as by fame, reaching this ſide of the mountains into *England*, until it had been brought thither from another very diſtant quarter.

For this method of *inoculating* the *Small Pox*, and that in a more orderly way, has been in uſe of a long time in *Circaſſia*, *Georgia* and ſome other neighbouring parts of *Aſia* [c]. It was brought to *Theſſaly* [d], and from thence, towards the end of the laſt century, made its way into the imperial city of *Conſtantinople* itſelf [e]. From whence it has been propagated into many parts of *Europe*: where being recommended by its

[a] Vid. Harris Prælect. de Inoc. Variol. p. 67.
[b] Phil. Tranſ. Abr. VI, 3. p. 127. 128. 129.
[c] Timoni in Phil. Tranſ. Abr. V, 1. p. 370.
[d] Pylarin. Ibid. p. 377. [e] Ibid. p. 370. 377.

great

great and extraordinary ſucceſs, it has been adopted by many Gentlemen of the profeſſion. Whereas formerly, before it came to *Conſtantinople*, it had been confined among the people, and managed ſolely by the lower ſort. And now it has reached even to ſome of the plantations of *America*[a].

32. We had no exact accounts of the appearances and periods of this artificial *inoculated Small Pox* until it came to be practiſed at *Conſtantinople*, where it began to be more carefully obſerved, than while it was confined to the ruder multitude. We could not reaſonably promiſe on any perfect uniformity in this matter. And yet even here I believe we ſhall find a regularity beyond our expectation.

A. Dr. *Le Duc* is indeed very indefinite. He ſpeaks as if the eruption might happen on the 1 or any ſubſequent day to the 7 after the *inoculation*[b]. He himſelf had the *fever* in the beginning of the 3: and on the 4 the puſtules appearing made him eaſy[c]. This you ſee is very vague. And I know

[a] Vid. Phil. Tranſ. Abr. VI, 3. p. 120. 137. 138.
[b] Diſſ. de Byzant. Variol. Inſit. §. 25.
[c] Ibid. § 26.

it

ESSAY I. it may moreover be objected he was then too young and raw to make or remember obſervations exactly.

Let us then therefore rather conſult *Timoni* and *Pylarinus*, who had ſkill as well as opportunity to make obſervations wherein we may confide. And they unanimouſly agree that the pox almoſt always appeared on the 7 day from the *inoculation* [a]; though they allow that, by reaſon of ſome idioſyncraſy in the patient, it may poſſibly happen otherwiſe. But when *Pylarinus* or others ſay that they may, though by way of a great rarity, have appeared on the very firſt day; from the whole ſcheme of this diſeaſe may we not ſuſpect there had been ſome antecedent infection in the natural way? All this is to be underſtood of the *inoculation* at *Conſtantinople*, where by the preſcription of the *Greek* woman, who introduced it, the room was to be kept always exceeding warm [b].

Dr. *Harris* ſays they never appear before the 7, and oftener on the 8 or 9 [c]. But in two of the four criminals, upon whom

[a] Phil. Tranſ. Abr. V, 1. p. 371. 379.
[b] Vid. Phil. Tranſ. Ibid. p. 371. 378. &c. Le Duc. Ibid. §. 18. [c] Præl. de Inocul. p. 65.

the

the experiment was made at *London July* 1721, the eruption happened on the 7, and a little ſooner in the other two of them [a]. But at that time the *Inoculation* was but in its infancy in *England*, where it ſoon came to be ſo much cultivated. So that Dr. *Nettleton* had in a ſmall ſpace of time above threeſcore patients in this way: whoſe obſervations, as having been done with the greateſt care and judgment, and often enough repeated, we may ſafely rely on. ESSAY I.

B. The firſt thing that occurred after inſition was the inflammation of the wounds, which commonly happened about the 4 day [b].

C. In about two Days more, to wit about the 6 of the *Inoculation*, they began to digeſt and run [c]. In ſome they begin to run ſooner, and the quantity diſcharged is much greater than in others [d].

D. About the 7 day the ſymptoms of the fever begin to come on.—In many not till the 8 or 9 day [e].

It was obſerved too in *New England* that they felt the uſual ſymptoms of the *Small Pox* about the 7 day [f].

[a] Jac. a Caſtro Diſſ. in Inoc. Variol. p. 37.
[b] Phil. Tranſ. Abr. VI, 3. p. 122. [c] Ibid.
[d] Ibid. p. 123. [e] Ibid. [f] Newman Ibid. p. 120.

E. In

ESSAY I.

E. In *England* on the 10 day (the 3 of the variolous fever) the *Small Pox* moſt commonly appeared, ſometimes on the 9, and ſometimes not till the 11. But Dr. *Nettleton* did not find that any difference of age, conſtitution, or any other cauſe ever made them vary above one day from the 10 [a].

And juſt ſo in *New England* about the 3 day from the decumbiture (or 10 of the *Inoculation*) the eruption begins [b].

In *Scotland* here the diſeaſe does not ſeem to have gone on ſo uniformly in theſe children whoſe *Inoculation* my friend Dr. *Steven-ſon* had the care of, who kindly communicated to me an extract of his notes. In them the *Pox* appeared ſometimes ſooner, ſometimes later, it may be on the 8, and ſometimes delay'd till the 11: however the moſt ordinary terms of eruption were the 9 and 10.

There was a remarkable anomaly in the *inoculated Small Pox* at *Haverford-Weſt* in *Pembrokeſhire* in the ſpring 1732; when in the time of an epidemic conſtitution of *Mea-ſles* the inoculation was performed. About the 7 came on a fever, which next day

[a] Ibid. p. 123. 125. [b] Newman Ibid. p. 121.

uſhered in the *Meaſles*. On the 12 another fever ſucceeded, which brought a very kindly *pox* on the 14 [a].

Was the very warm room, to which the patients were confined, the reaſon why the *Pox* appeared three days ſooner at *Conſtantinople*, than in *England* and *New England*, where they were under leſs ſtrict confinement, and indulged a cooler and more temperate air [b]?

F. Their appearance was the ſame with the mildeſt of the *diſtinct* kind [c]. But as to their duration our chief author himſelf is not ſo very explicit. However he lets us know that thoſe which were eaſieſt having made their appearance for 4 or 5 days, that is, till about the 14 of the *Inoculation*, they waſte inſenſibly away.

And exactly conform to this we are told, that in *New-England* on the 7 day of the fever, or 14 of the inoculation, the puſtules uſually arrive at their maturity, and ſoon after go away, as thoſe of the *diſtinct* ſort uſe to do [d].

[a] Davis in Phil. Tranſ. 429. p. 123. 124. 125.
[b] Phil. Tranſ. Abr. VI, 3. p. 120. 122.
[c] Nettlet. Ibid. p. 123. [d] Newman Ibid. p. 121.

ESSAY I.

But the termination of the *Pox* was more exactly obſerved by Dr. *Stevenſon*. When the *inoculation* went regularly on, the pox were at the height and began to blacken about the 15, it may be a day ſooner or later: though by ſome anomaly in the courſe of the diſeaſe this was in ſome patients protracted 3 or 4 days later. And about the 19 or 20 day of the Inoculation the *Pox* were moſtly dried off.

And ſo the *inoculated Pox* do ſeem very much to reſemble that extraordinary and very benign conſtitution of the *natural Small Pox* at *Utrecht* in *June* 1731, which were ſuppurated on the 6 day, and dried againſt the 9 [a].

33. From the *phænomena* of the ſeveral kinds of the *Small Pox* we find that in thoſe of a virulent nature the *contagion fever* is very violent, ſoon bringing on the *inflammatory* ſtate, and ſending forth the puſtules often on the 3 day, ſometimes on the 2, and it may be on the very firſt: whereas in the benign and *diſtinct* kind this fever is commonly eaſy, ſometimes not perceptible [b],

[a] Muſchenbr. in Phil. Tranſ. 426. p. 422.
[b] Pereir. Nov. Med. 69. p. 905. Sydenh. Oper. p. 133.

ending

ending for the moſt part with the *eruption* on the 3 or 4 day from the firſt attack.

The puſtules gradually ſwell and ſhew their contained liquor every day more and more opaque, till they are pretty large, and contain perfect true *pus*. The *maturation* and *drying* of which, and the *declenſion* of the diſeaſe, contrary to the method of the *contagion fever*, take up a longer ſpace in the *confluent*, than in the *diſtinct* kind. And the more confluent and virulent the *pox* are, theſe laſt *ſtadia* are the more tedious, imperfect and dangerous to the unfortunate patients.

But we find the artificial *inoculated Pox* to be the eaſieſt, and ſooneſt over of all. The *contagion fever* is eaſy and ſhort, ſending forth the *pox* in a very kindly way, which come to maturity in 4 or 5 days, that is about the 7 day of the variolous fever (3 or 4 days ſooner than even in the ordinary *diſtinct* natural kind) and ſoon fall away.

34. The *Meaſles* ſeem to have come into the world with the *Small Pox*, and were always reckoned ſo much akin to them that both uſed to be treated of together under

ESSAY I. one head. But the later writers have more adviſedly conſidered them ſeparately.

A. At *London ann.* 1670 there aroſe a very orderly and regular conſtitution of the *Meaſles*. On the 1 day the ſick ſuffered rigors and ſhiverings, and alternate returns of heat and cold; which on the 2 day landed in a regular fever with peculiar ſymptoms [a].

B. Theſe ſymptoms increaſed till the 4 day (ſometimes the 5) when the *Meaſles* appear on the face; from whence gradually they ſpread themſelves over all the body [b].

Ann. 1674 they were not near ſo regular either in the manner or time of the eruption [c]. *Mercurialis* had commonly obſerved their firſt appearance on the 2 or 3 day [d]. And *Morton* ſays that this firſt *ſtadium* of the *Meaſles* is of a different duration according to the various nature of the fever *&c* [e]. But in the moſt benign ſort, and ſporadic *Meaſles* it laſts 2 or 3 days, and then the eruption comes on; the later as on the 5, 6 or 7 the worſe [f]: as *Diemerbroek* had likewiſe placed

[a] Sydenh. Oper. p. 196. 588. [b] Ibid.
[c] Ibid. p. 232. [d] De Morb. Puer. I, 2. p. 258.
[e] Pyretolog. III, 3. p. 20. 26. III, 5. p. 44.
[f] Ibid. 3. p. 26. 5. p. 44.

their ſlow appearance amongſt the evil prognoſticks [a].

C. On the 6 day of the regular epidemic kind *ann.* 1670 the face turns rough; and the puſtules that were raiſed above its ſurface break and fall off, and leave nothing but red ſpots, ſuch as are thoſe of the reſt of the body, where they are juſt now at their height in largeneſs and colour [b].

D. *Mercurialis* ſays many of the *Meaſles* are gone off againſt the 7 day [c]. And ſo *Sennertus* [d] and *Diemerbroek* [e] ſay they evaniſh after the 7 day, yea oftentimes ſooner. Thoſe at *Auſburg ann.* 1703, obſerved by Dr. *Shroeckius*, performed their courſe in 8 days [f]. And in *Sydenham*'s abovementioned moſt regular *morbillous conſtitution ann.* 1670 on the 8 day the ſpots of the face went off, and the day after were followed by thoſe of the reſt of the body: and in their place the ſkin had, as it were, a furfuraceous roughneſs over it all [g]. Which however was wanting in the *Meaſles ann.* 1674 [h].

[a] De Variol. &c. 13. p. 289. [b] Sydenh. Oper. p. 197. 588. [c] De Morb. Puer. I, 2. p. 258. [d] De Febr. IV, 12. p. 830. [e] De Variol. &c. 13. p. 289. [f] Conſt. Epid. Auguſt. 1703. p. 348. Oper. p. 197. 588. [g] Ibid. p. 232.

ESSAY I.

E. About this time the fever, *dyſpnœa* &c. are often increaſed [a].

35. *Febris Scarlatina* is but ſlightly touched by *Sydenham* [b]. It were to be wiſhed he had handled it with more care. *Morton* alledges it is intirely of the morbillous kind, having the ſame cauſes, ſymptoms, &c. obſerving the ſame *criſes* and *periods*, and requiring the ſame management and cure; ſo that he would chooſe to reckon it, as it were, the *confluent Meaſles* [c].

With the *Scarlet Fever* that ſpecies of eruption ſeems to coincide, which *Ingraſſias* tells us in his country is called *Roſſania* or *Roſſalia* [d]: whoſe *periods* coincide exactly with thoſe of the *Meaſles*; the eruption coming out the 4 or 5 day of the fever, and going off about the 7 or 9, with furfuraceous ſcales on the ſkin [e]: herein agreeing with the exit of *Sydenham*'s *Scarlet Fever* [f].

It is of this *Fever* I underſtand Mr. *de Baillou* when he ſays "RUBIOLÆ *diutius* "*manent, & ſua habent tempora & pa-*

[a] Sydenh. Ibid. p. 197. 588. [b] Ibid. p. 260. 581.
[c] Pyretolog. III, 3. 5. [d] De Tumor. p. 194, &c.
[e] Vid. Sennert. de Febr. IV, 12. p. 830.
[f] Oper. p. 232. 260. 581.

"*thognomica.*"

" *thognomica* [a]." And to it too are to be reduced the *Purpuræ* or Ερυθημαλα of *Forreſtus* [b]; as alſo, I think, the *German Rittein* or *Rottein*, though *Sennertus* ſpeaks of it as a different diſeaſe from the *Purpuræ* or *Roſſalia*, as well as from the *Meaſles* [c].

36. The other kinds of *Efflorescent Fevers* do not ſeem to have ſuch orderly and regular *ſtadia*, as thoſe of a *variolous* and *morbillous* nature, and therefore their *periods* cannot ſo well be ſettled, though ſome of them may perhaps have been ſeen by the *Greeks*, as well as by the phyſicians of the ſucceeding ages. However that be, ſure we are that the Εξανθημαλα or Εξανθησιες, and Εκθυμαλα, and Τρηχισμαλα, and Αναδηγμαλα ὡς ὑπο κωνωπων of the ancients [d] either had no regular periods, or they were not

[a] Epid. I. ann. 1574. p. 55.
[b] Obſ. Med. VI, 59.
[c] De Febr. IV, 12. p. 829.
[d] Vid. Hipp. Aph. III, 20. VI, 9. Coac. II, 162. IV, 19. II. Prædict. XXXVI, 19. XLIX, 2. I. Epid. II, 69. III. Aegr. II, 29. II. Epid. I, 49. II, 36. 46. III, 21. III. Epid. III, 82. IV. Epid. XXVII, 15. V. Epid. XXXIII, 9. VI. Epid. II, 52. VII. Epid. XLI, 31. LII, 1. Celſ. Medic. V, 28. §. 15. p. 336, 7. Galen. Meth. Med. V, 12. De Diff. Febr. I, 3. De Succor. Bon. &c. I. De Tumor. 9. Aët. Tetrab. V, 129. XIV, 63. Paul. Aeg. IV, 8.

ESSAY I. observed and defined by these otherwise so accurate observers of the *courses* of diseases.

37. But what if in some things the moderns may have been more exact than the ancients themselves? The *Febris Miliaris* treated of by Sir *David Hamilton* is of the *Efflorescent* kind, and is a very distinct species, accompanied with peculiar symptoms, and performing its course in regular periods of time, if it always really come up to his description. As far as he could find out, he reckoned the pustules to appear for the most part on the 10 or 11 day from the beginning of the fever, if it had a regular course: and that they were dried about the 18, or, when the morbific matter was in greater abundance, about the 21 or 22 day[a]. But as he himself allows of great difficulties in determining this matter, and succeeding authors have not much considered this fever; and as I, though I have seen it, have not had sufficient opportunities to ascertain its periods, I must leave it to be farther examined by future observations.

In the mean time I make no doubt that there may be *Miliary Fevers* differing very much

[a] De Febr. Mil. p. m. 534.

much from that of Sir *David Hamilton*. Of this kind I take the *Purpura Alba* to be in the *Wratiſlaw* journal of diſeaſes *ann.* 1700; wherein about the 4 day, or a little ſooner the ſkin aroſe into ſmall aſperities reſembling a gooſe ſkin, which turned into an infinite number of little pellucid puſtules, which in thoſe of a drier habit ripened, and fell off in 24 hours, but in the plumper and younger ſort laſted ſome longer, and burſting threw out a little ichor with itching and heat [a].

38. *Petechial* or *Flecky Fevers* have ſubſiſted time out of mind, and are endemial in ſome places, as in *Cyprus* and the neighbouring iſles [b]. But ſince that *ann.* 1505 and 1528 they came into *Italy*, and raged ſo remarkably there, and were on that account particularly treated of by *Fracaſtorio*, they have been more carefully taken notice of by ſucceeding writers on *Fevers*. *Falloppio* too reckons the *Lues Peticularis* a new malady, dating it from 1505, or 40 (printed, I ſuppoſe, for 50) years before the time he was giving his lectures on the

[a] Conſt. Epid. Uratiſl. 1700. p. 334.
[b] Fracaſtor. de Morb. Contag. II, 6.

French

ESSAY I.

French Diſeaſe [a]. In the *Petechial* conſtitutions, by *Fracaſtorio*'s account, the *flecks* appeared in form of flea-bites about the 4 and 7 days [b].

We had already occaſion to obſerve that in thoſe at *Modena ann.* 1692 the ſpots appeared all over the body about the 7 day, §. 15. FF: but about the 3 in thoſe at *Cologn ann.* 1672 *&c.* §. 15. DD: and ſo ſoon as the 2 or 3 in that malignant *petechial* conſtitution at *Mansfeldt ann.* 1697, §. 15. KK.

Pereira ſpeaks of *flea-bite* or *pulicular flecks* (for of them rather than the common *Meaſles* I would underſtand his *Spaniſh Tavardillo)* as appearing on the 4 or 5 day, or afterwards [c].

Even *Hippocrates* himſelf had occaſion to ſee ſomething of this kind. In the ſummer *fevers* in *Perinthus* many women had *flecks* like *fly-bites* appearing about the 7, 8 or 9 day, and laſting till the *criſis* on the 14, wherein they always recovered [d]. On another occaſion he mentions one *Pherecydes*, who had ſuch eruptions on the 8 day [e].

[a] De Morb. Gallic. 1. p. 683.
[b] De Morb. Contag. II, 6. p. 159.
[c] Nov. Med. 48. p. 659. [d] II. Epid. III, 21.
[e] VII. Epid. XLI, 31.

We find no exquiſite regularity or order in all this. Nor will you think it any wonder if ſuch fevers obſerve no very regular courſe. Where ever ſuch *flecks* appear they argue a more than ordinary diſſolution of the blood, are often contagious, commonly dangerous, and reckoned in ſome meaſure peſtilential, or tending that way.

39. And indeed we could not expect great uniformity in theſe terrible viſitations upon mankind, which go under the name of the *Plague*, and *Peſtilential Diſeaſes*, or are any way akin to them. Yet even theſe ſeem to conſtitute ſpecieſes by themſelves, or to be ſpecifically different one from another, as well as from all other diſeaſes. Some *Plagues* ſeize only on the vegetable kingdom, ſome on the brute creation, and that ſometimes on one kind of animals, ſometimes on others, ſometimes on man and beaſt, and frequently man ſeems to be the only ſufferer. Yea thoſe of a given conſtitution are tolerably uniform in their ſymptoms, and, what is very ſurpriſing, beſide other characters of regularity, do commonly kill in determined ſpaces of time.

ESSAY I.

A. The *Peſtilence* which God uſed to ſend upon mankind for the vindication of his honour and power; and upon his peculiar people, as a chaſtiſement for their tranſgreſſions; ſeems to have killed the unfortunate victims in an inſtant, at leaſt the very firſt day of the diſeaſe.

On the morrow after *Moſes*'s denunciation the *Cattle* of *Egypt* of all the ſeveral kinds died of a grievous *Murrain* [a]. And a few days after at midnight in a moment the Lord ſmote all the firſt-born of man and beaſt in that great kingdom, which belonged to the proud and ſtubborn *Pharaoh* [b]. So likewiſe many ages after, to protect his own people, and to humble the boaſting king of *Aſſyria*, the blaſt of the Lord went out, and quite diſcomfited him, and ſmote in the night time a great part of his numerous and victorious army [c].

The people of *Iſrael* murmured at the untimely and exemplary, though very miraculous death of *Korah* and his company, ſo that God in his anger, threatning to conſume them all in a moment, ſent a dreadful *plague*, which immediately, before an

[a] Exod. IX, 6. [b] Ibid. XII, 29.
[c] Iſai. XXXVII, 36. II. Kings XIX, 35.

atonement

atonement could be made, killed a great many [a]. And King *David*'s vain-glorious numbering of his ſubjects drew down a ſudden *peſtilence* upon the unfortunate multitude, whereof many thouſands fell a ſacrifice for his fooliſh oſtentation [b].

B. *Ann.* 1167 a *plague* broke out in the army of the Emperor *Frederick Barbaroſſa*, ſuddenly killing very many, eſpecially Generals, Prelates, and other great men [c].

C. We formerly (§. 20. B.) took notice how ſuddenly the *Engliſh ſweating ſickneſs* uſed to kill, ſo as to have the look of a *Peſtilence*, before the management and cure of it was thoroughly underſtood. And ſome thought it akin to the *Peſtilences* in the *Greek* army before *Troy*, in the *Cantabrian* war, and in the ſiege of *Rhodes* [d].

D. *Forreſtus* gives us an account of an epidemic *Squinance ann.* 1517, which, if not well taken care of, killed ſuddenly in 16 or 20 hours [e]. And ſo likewiſe *Sennertus* tells us of another *Squinance ann.* 1564, which he calls dangerous and peſtilential,

[a] Numb. XVII, 45—49. [b] II. Sam. XXIV, 15. I. Chron. XXI, 14. [c] Baron. Annal. Eccl. ann. 1167. [d] Vid. Caium de Eph. Brit. p. 21. 53. [e] Obſ. Med. VI, 2. p. 190.

by

ESSAY I. by the malignity whereof some died the very first day, some the 3 and others the 4 [a].

E. Of those who were destroyed by the *Plague* in *Italy* and most other parts of *Europe ann.* 1565, 1566, wherein the female sex and boys chiefly suffered, some died on the 1 and 2 day, most about the 4, few survived the 5 [b].

F. *Ann.* 454 there was a *Plague* in *Asia Minor*, &c. wherein the persons affected swelled, then lost their sight, and a cough coming on the 3 day they died [c].

G. And *ann.* 565 in *Italy* and in the northern countries was a *Pestis Inguinaria* which killed in 3 days. If they survived this period there were hopes of recovery.

H. In the middle of the 14 century a most terrible *pestilence* overran the world, scarce leaving a fourth part of mankind alive, if *Guy de Chauliac* computed aright. In 1348 it attacked *Avignon* where he resided, and appeared in two different shapes. In the first, which was the most violent and infectious, the sick had a fever and spitting

[a] De Febr. IV, 17. p. 843. [b] Mercurial. Lect. de Pest. I. p. 6. [c] Evagr. apud Baron. Ibid. ann. 454.

of

of blood, and died in 3 days. The ſecond was not hæmoptoical, but ſuperlatively inflammatory too, having the fever, abſceſſes and carbuncles, and killing in 5 days [a]. *Boccacio* ſpeaks of this ſame *Plague*, which he had the mortification to ſee raging at *Florence*, in a very lively and paſſionate manner. It does not ſeem there to have been accompanied with any hæmoptoe, or violent fever: but it immediately roſe into *Bubos* in the groin and armpits, and killed in 3 days [b]. Nay frequently ſooner: for he very pathetically laments the untimely fate of many in their full vigour, and in the bloom and pride of youth, ſeemingly well, and in health in the morning, and ſuddenly ſnatched away before night from their diſconſolate friends.

ESSAY I.

Dr. *Freind* ſpeaks as if this *hæmoptoical Peſtilence* had viſited the world a ſecond time in the beginning or middle of the 16 century: for treating of this *Plague* of *Guido*'s, he ſays it was "much like what "afterwards *Fracaſtorius* obſerved in his "time [c]." But I fear that truly learned man has, through the multiplicity of

[a] Chirurg. II, II, 5. p. 104. [b] Dicam. I. Præf. p. 20. [c] Hiſt. of Phyſ. II. p. 323.

books

ESSAY I. books and things he had to consider, fallen into a mistake in this particular. I cannot find any account of such a *plague* appearing in that age in *Fracastorio* himself, or any of his contemporaries. In his book *De Morbis Contagiosis*, where he had the fairest opportunity of mentioning such a disease, he says nothing of that kind. The few lines he has of such a *plague* in his *Syphilis* come in, as it were, by way of example or illustration, and for the embellishment of his poem. The story he takes from *Guido*, and other old authors, manifestly alluding to that universal *pestilence* which had raged 200 years before himself. *Bis centum fluxere anni, &c*[a]. It seems it did not in all places kill precisely on the 3 day, if *Fracastorio* had good authority when he said

"*Quarta* luce frequens fato perdebat acerbo[b]."

I. At *Oedenberg* in autumn 1713 there arose a contagious epidemic illness, attended with vomiting and great heat in the belly, killing on the 3 and 5 day. In some there were black petechial spots, and other *pesti-*

[a] Syphil. I, 186. [b] Ibid. 191.

lential

lential ſymptoms, whereby death enſued on the 7 and 9 [a]. ESSAY I.

K. *Ann.* 1586 in ſome places in *Italy*, as at *Baſſana* and *Maroſtica*, there raged an epidemic *Pleuriſy*, *peſtilential* and contagious, which killed on the 4, or at fartheſt on the 7 day [b].

L. *Forreſtus* ſpeaks of the *Peſtilential fever* ann. 1545 as having its criſes at very diſtant ſtages, ſometimes on the 4, and ſometimes on the 11 day [c].

M. In the *Lower Hungary* in the ſpring 1713. malignant *Petechial fevers* came in, killing with great ravings on the 5 day [d]. A peſtilential conſtitution reigned all that year [e], and we had already (I) occaſion to take notice of ſome of its effects in autumn.

N. *Braſavolus* has no favourable opinion of the 6 day more than his maſter *Galen*. He takes it for a general rule, though I think he is therein miſtaken, that in *peſtilential* diſeaſes for the moſt part the affected die on that day. Be that as it will it ſeems

[a] Genſel. Conſt. Epid. Hung. 1713. p. 807.
[b] Alpin. De Præſag. I, 11. p. 51. VII, 19. p. 523.
[c] Obſ. Med. VII, 7. p. 197.
[d] Genſel. Ibid. p. 802. [e] Ibid. p. 805. 806.

ESSAY I. to be no favourable day to expect a good *crisis* in such diseases more than in others. He assures us from an infinite number of observations, that in the epidemic constitution *ann.* 1528 almost all died on the 6 day [a].

O. And exactly consonant to this *Diemerbroek* tells us that in the *Plague* at *Nimeguen* ann. 1635, 1636, 1637 nothing certain and constant could be promised upon from the *crises* happening on the regular *decretory days*. But these that came on the 6 were always undoubtedly mortal [b].

P. And in a *pestilential Pleurisy ann.* 1565 almost all died about the end of the 6 day [c].

Q. *Pereira* observed a *Pestilential fever*, wherein a *Diarrhœa* coming on the 6 or 7 day quickly killed the sick. But in others a deafness coming on the 11 portended a recovery [d].

R. The famous *Athenian plague*, which committed such ravage in that city in the time of the *Peloponnesian* war, described in a most lively manner by *Thucydides*, and al-

[a] Com. in Hipp. Aph. II, 24. apud Diemerbr. de Pest. I, 15. p. 70. [b] Ibid. p. 67. [c] Sennert. de Febr. IV, 17. p. 843. [d] Nov. Med. 66. p. 876.

most

moſt intirely copied from him by *Lucretius*, killed commonly againſt the 9, and ſometimes the 7 day[a]. *Lucretius* ſays the 8 or 9[b]. ESSAY I.

40. Thus we have confirmed to us by numberleſs examples the regularity of *Epidemic* diſeaſes, not thoſe only of a more benign kind, but even theſe of a peſtilential nature: and that they of a given ſort and conſtitution obſerve much the ſame *times* and *periods* in different perſons and places. A remarkable inſtance of the uniformity of human nature even in a depraved and corrupt ſtate.

41. The doctrine of *Criſes* and *Critical Days* was the child of experience, and nurſed up in daily obſervation. *Atque hæc, ut ego arbitror, veteres rerum magis eventis emoniti, quam ratione ducti probaverunt*[c]. And thus far taking it as a piece of *Natural Hiſtory*, that is, as a collection of facts, or of the phænomena of diſeaſes, it makes a very elegant and uſeful part of medical knowledge. But the mind of man is a reſtleſs and curious being, is ſeldom ſatisfied with

[a] Hiſt. II, 49. [b] De Rer. Nat. VI, 1195.
[c] Cicer. De Divin. I, 3.

ESSAY I.

a bare hiſtory of facts, and would always gladly penetrate into the cauſes of things, and ſee the various ſprings, laws and inſtruments of action, the knowledge of which we call *Natural Philoſophy*. A moſt delightful ſcience when chaſte and free from all falſe ſuppoſitions and fictitious reaſoning, as *Natural Hiſtory* is only to be valued, when diſengaged from fable and inſignificant ſtories.

Hippocrates was ſenſible of the inſufficiency of the human faculties to explain the nature of one ſpecies of facts without the aſſiſtance, and, as it were, borrowed light of a great many others. And therefore, though he had with incredible pains made and collected very many obſervations concerning the *criſes* and *events* of various diſtempers; yet conſcious of a great deal of the neceſſary *data* being yet wanting, very ſlightly touched upon the explanation of the variety of the *periods* of diſeaſes: and only regiſtering the facts he had obſerved, left the Philoſophy of them to the inquiries and induſtry of future ages. To him may be applied what was ſaid by *Cicero* on another occaſion and a very different ſubject.

" Quarum

" Quarum quidem rerum eventa magis ar- ESSAY I.
" bitror quam cauſſas quæri oportere [a]."

42. The plain and naked hiſtory of *Criſes*, as laid down by *Hippocrates*, was not allowed to ſubſiſt long in its original ſimplicity. Thoſe who knew vaſtly leſs of nature, than he, would however go beyond him, and explain the reaſon and connexion of *Critical Days* in a philoſophical way. This was undertaken by the Metaphyſical Phyſicians, who making uſe of ſome meaningleſs words and unintelligible expreſſions of *numbers*, injudiciouſly borrowed from the *Pythagorean philoſophy*, thought they had in a few words given a reaſon for the extraordinary *harmony* that was obſerved in the duration of diſeaſes. But *Galen* and others have ſufficiently ſhewn how improperly thoſe *numbers* of *unity*, *binary*, &c. are applied in this matter, and how abſurd and improper their explanations were [b].

43. *Galen* himſelf, as he attempted every thing, could not leave this matter untouched. He has aſcribed the reaſon of the ob-

[a] De Divin. I, 6. [b] De Dieb. Decr. III, 8. 11.

ESSAY I. ſerved *Critical Days* chiefly to the conjunct operations of the *Sun* and *Moon* [a]: the period of which laſt planet he was obliged to repreſent in a very ſingular and unnatural way, to make it agree with the received phænomena of *Criſes* [b]. But in this undertaking, though he has been implicitly followed by many, he has laid himſelf open to be confuted by all thoſe who had the courage and freedom of mind to diſſent from him. And by his bad ſucceſs has ſhewn the difficulty of the ſubject: whereof, to do him juſtice, he was ſufficiently aware; when he tells us, and takes God to witneſs for the truth of what he ſays, that he had not of his own accord undertaken this taſk, which he would gladly have declined; but at the earneſt and irreſiſtible ſolicitations of his friends [c]. So that I am apt to think he has rather given us what had and might be ſaid on that ſubject in an Aſtrological way, and after the manner of the *Egyptian* Phyſicians [d], than his own real opinion of the *philoſophy* of *Criſes*, which certainly he thought very intricate.

[a] Ibid. 2, &c. [b] Ibid. 9. [c] Ibid. 11.
[d] Vid. Ibid. 6.

44. So

44. So that I cannot but commend the modeſty and reſerve of *Avicenna*, who indeed is at the pains to give us a ſhort ſketch of the common *Galenical* accounts of this matter, but at the ſame time ſignifies his diſtruſt of them; and looks upon the *Criſes* and *Critical Days* as ſo many obſervations, the truth of which we know from experience, but the reaſon whereof was not ſo evident or ready at hand, and belonging rather to the *Philoſopher* than to the *Medical* Phyſician [a]. And this has ſcared moſt of the ſucceeding authors, who generally ſeem to aſcribe the whole to *Nature*, and think they have ſufficiently explained the matter, when they tell us that *Nature* being burthened with ſuch and ſuch loads of noxious humours (the *periodical revolutions* of which ſome writers pretend to determine) is at length by their ripening irritated to expel them out of the body.

45. This you ſee is juſt falling back again into the indefinite obſervations of *Hippocrates* of Νουσων φυσιες ιηϱοι, and φυσις τας νουσους κϱινει, and φυσις ἐξαϱκεει ϖανϑα ϖασιν, &c.

[a] Can. IV, II, II, 2.

ESSAY I.

And indeed what can we ſay more of the ſettled times of the duration of diſeaſes, than of other analogous operations of nature? We ſee the incubation of Eggs accompliſhed juſt in determined ſpaces; every ſpecies of birds and fowls having its own peculiar appointed time, wherein, neither ſooner nor later, the young chickens are brought to light. We ſee the ſame thing holding in the pregnancy of viviparous creatures, who all have their ſettled times of geſtation, and due limits of regular births, there being ſeldom any great anomalies in this reſpect; ἐκαστων εν τεταγμενοις καιροις επιγενομενων [a]. And ſo too of the increaſe, and adult ſtate, and decay, and death of animals: all which have their determined ſpaces of duration, or arrive at their ſeveral *ſtadia* in determined times; moſt of the individuals of each ſpecies, if left to the ordinary and regular courſe of nature, obſerving pretty nearly ſome certain rules, which are but ſeldom tranſgreſſed in any conſiderable degree.

46. Now in order to apply this to diſeaſes, let us call to mind what *Hippocrates* ſeems to have thought, and what we already

[a] Pythagor. apud Diog. Laert. VIII, 29.

found

found *Sydenham* expreſsly affirming, that given *Diſeaſes* are peculiar modifications of the body, and, as it were, particular beings, all different one from another, and diſplaying themſelves in ſuch and ſuch particular manners, and exerting their ſeveral operations in given determined ſpaces of time. And *Malpighi* [a] and *Borelli* [a], as well as *Sydenham* [b], unanimouſly take it for granted that, as the commotions or fermentations of liquors laſt certain ſpaces, ſo the ſeparation of a certain portion from the maſs requires ſome determined lengths of time to be regularly accompliſhed. Conform to which *Bellini*, even when he is diſputing againſt the *Critical Days* of the ancients, tells us that, as the planets go their rounds in ſettled periods, ſo different humours require different ſpaces of time for their perfect maturation, ſo as to bring on *criſes* ſooner or later according to the various nature of thoſe humours: juſt too as the duration of plants and trees are ſhorter or longer according to their various original fabric and conſtitution [c]. And he acknowledges

ESSAY I.

[a] Malpigh. Vit. Poſth. p. 22. 23.
[b] Oper. p. 80. 88. 89. 145. 165.
[c] De Miſſ. Sang. X. p. 243. 244.

that

ESSAY I. that it is by experience alone we can know the force of any diſeaſe, and the time it takes to exert its violence [a]. Dr. *Cheyne* obſerves that determined cauſes produce determined effects, and a determined degree of ſizineſs of the blood, all other circumſtances continuing the ſame, will require a determinate time to be duly diluted, broken and thinned [b]. And Dr. *Boerhaave* taking the morbid ſtate of the blood, or its viſcid *diatheſis* in a chemical view, finds a definite time requiſite for its diſſolution. "In ægrotantis corpore "ſtagnans in vaſis obſtructis, leni tepore, "& tempore, ſponte deliqueſcens, ſæpe "aperit quæ obſtruxerat: unde in inflam-"matoriis acutis, corporis calore ad media-"crem reducto, *ſpatio definito dierum* mea-"bilitas redit obſtruenti [c]."

Indeed the reaſon of the various natures and durations of diſeaſes and other ſuch like natural proceſſes in animals and vegetables, and other ſubjects, we muſt deſpair of underſtanding thoroughly, untill we be better acquainted, than we are at preſent, with the minute particles of matter, their figures, motions, laws of action, *&c.* from whence

[a] De Morb. Cap. p. 468. [b] Of the Gout, §. 9.
[c] El. Chem. II, 115. p. 351.

flow

flow moſt of the operations of nature. ESSAY I.
" *Latet fortaſſe cauſſa obſcuritate involuta*
" *naturæ*[a]."

47. There is however a very remarkable article in the doctrine of *Criſes* we may pretend to give ſome illuſtration of. In given *conſtitutions* the regular returns of *intermittent fevers*, and the various *ſtadia* in other diſeaſes appear pretty uniform, and nearly the ſame in all perſons of a hale and vigorous enough make; whether young or old, men or women, of a larger or ſmaller ſize, *&c.* This muſt appear very ſtrange at firſt view, when every body is ready to think that the circulation of the blood has various periods in the body, widely differing one from another in different animals, according to theſe various circumſtances.

But if we will take the pains to examine the affair more narrowly, we ſhall find that, if animals of however different ſizes be tolerably ſimilar, the circulations of their liquors in the correſponding veſſels, and every thing depending thereon, ſhall be performed in pretty nearly the ſame ſpaces of time; ſo

[a] Cicer. de Divin. I, 18.

as

ESSAY I. as that the *Stadia* and *Criſes* of diſeaſes of a given conſtitution ſhall fall out much in the ſame way and periods in boys and adults, in men and women, in dwarfs and giants *&c.* But as this affair deſerves a particular conſideration, I muſt be allowed to tranſcribe what is ſaid on this ſubject from another treatiſe concerning *Similar Animals*; which ſhall in ſome ſort ſum up and conclude this preſent eſſay, which I find has grown on my hand to a much greater length, than what at firſt I intended or expected.

" PROP. XI. Liquores per vaſa *Similium* " *Animalium* commeantes tranſeunt per ho- " mologas vias vel diſtantias in *eodem tempore*.

* * * \

" *periodicarum*, aliorumque morborum ſtatis
" *temporis* intervallis redeuntium, ex hac
" doctrina rationem reddere poterimus, qua-
" re hi, qui ſunt ejuſdem, ut ita loquar,
" genii & conſtitutionis, iiſdem ſymptoma-
" tibus ſe prodentes, iiſdem quoque ſtatis
" *temporibus* in hominibus, vel minoris vel
" procerioris ſtaturæ, regulariter redeant, niſi
" ab accidente aliquo extrinſecus adveniente
" ordo naturæ perturbetur.

" COROL. 4. Ex hiſce quoque principiis,
" & penitiore humorum noſtri corporis con-
" ſideratione datur intelligere, qua ratione,
" ſecundum curatas probatiſſimorum medi-
" corum obſervationes, plerique regulares
" epidemici morbi datæ ſpeciei in omni-
" bus fere ægris, nec aliis, præter illos,
" morbis, nec incongrua medendi methodo
" vexatis, in iiſdem fere definitis *temporis*
" *ſpatiis* diverſa ſua *ſtadia* decurrant: &
" ſimul integri ipſorum morborum decurſus
" *ſtatis temporibus* plerumque abſolvantur,
" modo negotium naturæ permiſeris. Quæ
" benigna natura in multis morbis opus
" ſuum ſuo tempore exſequitur, materiam-
" que morboſam debito ordine ac via tum
" ſecernit, tum etiam expellit; ut noſtra

ESSAY I.

" ope, noſtris artificiis atque auxiliis non
" indigeat, ſuis viribus optime inſtructa,
" ſuis opibus locuples, ſuo denique ingenio
" ſatis edocta.

" SCHOL. Videas etiam an non ex me-
" chanicis hiſce legibus, ſi præſertim in ſub-
" ſidium advocaveris chemicas quaſdam con-
" ſiderationes & principia, aliqualis lux in-
" ferri queat adhuc haud ſatis explicatæ, &
" propterea a multis temere nimis rejectæ,
" doctrinæ *Hippocraticæ* de *morborum febri-*
" *lium Criſibus* & *Periodis*; quam longa &
" diligente obſervationum ſerie ſtabilivit ſa-
" gaciſſimus ejus auctor, in praxi ſimpliciſſi-
" mus, atque perraro hypotheſium ſectator.
" Atque cum plurimæ morborum hiſtoriæ
" ab accuratioribus quibuſque apud alias
" gentes, aliiſque temporibus notatæ, &
" præſertim hoc quaſi noſtro ſæculo, & hiſce
" regionibus a candidiſſimo *Sydenhamo*, de-
" ſcriptæ, adeo conſentientes videantur an-
" tiquis medicinalibus *Coorum* obſervationi-
" bus; dixeris forte tibi, priſcam doctrinam
" amplexanti, a recentioribus quibuſdam
" Aſclepiadis æmulis, qui naſutiores videri
" volunt, fruſtra objici diverſitatem clima-
" tum, & diverſitatem temperamentorum

" particularum

" particularum humani corporis, *quo minus* " *certo aut legitimo* tempore *ægritudines* " *ſolvantur* ; *aut iidem* dies *apud nos* Critici " *ſint*, *qui* Hippocrati & Galeno *fuerunt*.

" Et ſi quando pro veterum κρισεων " doctrina penitus convellenda ad experien- " tiam provocaverint *Hippocraticorum* dog- " matum contemptores, ſcio te, ſi ab anti- " quorum partibus ſtare volueris, continuo " regeſturum hodiernorum experientiam pa- " rum in hacce valere cauſſa. Quam uti- " que argueres juxta varias variorum hypo- " theſes inſtitutam, inconſtantem, inter- " dum malefidam, mille caſibus obnoxiam, " impropriis denique medelis turbatam. " Simplicem enim illam *Hippocratis* meden- " di methodum, naturæ tantum miniſtran- " tem, non imperantem, adſpernantes, con- " ſilium & molimen ipſius, morbum ad " *Criſim* debito tempore ut plurimum per- " ducturæ, gnaviter interdum fruſtramur " inutili noſtra ope, & ingrata medicamen- " torum farragine [a]. Quibus regulares & " ſpontaneas *febrium criſes* interturbamus, " contra genium & naturam morbi pauca

[a] Vid. Galen. de Dieb. Decr. I, 11. Bagliv. Prax. Med. II. 12. Malpigh. Op. Poſth. p. 80. Mead de Imp. Solis, &c. p. 59.

ESSAY I.

" pharmaca poſcentis, ſi *Hippocraticis* ora-
" culis fidere voluerimus. Cujus methodum,
" experientia edoctus, ſecutus eſt ſagax
" *Sydenhamus*. Quos auctores nos quoque
" imitemur, & forte veridicos comperiemus,
" ſi feliciter mederi velimus."

Homo Naturæ miniſter & interpres tantum facit & intelligit, quantum de ordine Naturæ, opere vel mente obſervaverit.

Bacon.

AN

AN

ESSAY

ON THE

Specific Operation

OF

Cathartic Medicines.

Non fingendum aut excogitandum, ſed inveniendum quid Natura faciat aut ferat.

Bacon.

AN

ESSAY

ON THE

Specific Operation

OF

CATHARTIC MEDICINES.

THE human body in exerting its natural and ordinary operations is liable to waſte and decay. So that a conſtant ſupply of meat and drink is rendered neceſſary, to keep it in an intire, firm and vigorous ſtate.

2. But our aliments are not made up altogether of nutritious parts. Many of them are uſeleſs, and ſo muſt be thrown out of the body along with thoſe indigenous particles, that had become unfit for any farther ſtay in the animal.

3. In the *primæ viæ* there is a concourſe of very many different ingredients of various

ESSAY II.

natures, and coming from very distant quarters. A great deal of *Saliva* from all the various salivary glands about the mouth; a salival lymph from the *Pancreas*, and from other excretory openings along the whole alimentary conduit. This has likewise every where scattered on its inside a great many lenticular glands, which, with the *Amygdalæ* of the *fauces*, furnish to the whole passage sufficient plenty of a lining *mucus*. And that great *viscus* the Liver contributes a large share of bile. All these various liquors are blended with our meat and drink, and undergoing a new mixture and digestion in the stomach and intestines, the more attenuated, purer and better parts are taken up by the absorbing vessels; while the gross, useless or noxious parts, as well of the indigenous liquors, as of the new *ingesta*, are thrown out of the body in the form of abominable excrements.

4. But this is not the sole outlet that nature has contrived for freeing the body of what is useless or hurtful to it. Some parts of the aliments are subtile enough to be taken up into the blood, but not fit to dwell with it long, or to be amongst the number of

of its ingredients, conſidered in a more perfect or defecated ſtate. And even the pure blood itſelf is always in a degenerating way. By the circulation and neceſſary animal functions many of its parts are ſpoilt, and grow too acrimonious to be conveniently retained in the body. So then we ſee a neceſſity of appointing ſome *viſcus* as an emunctory, where a great torrent of blood conſtantly arriving may be freed from theſe uſeleſs parts, both from the new *ingeſta* and from the corrupted indigenous liquors. This great cleanſing work is performed by the kidneys, ſeparating the urine from the maſs of blood, and thereby purifying it from its putrid and more acrimonious particles.

5. However the blood is not yet purified enough. Many of its more ſubtile and noxious particles eſcape the kidneys, and would ſtill lurk in the circulating maſs, were it not for the lungs and ſkin. Theſe two taken together may be conſidered as the laſt, moſt univerſal and great emunctory. There what of the blood and aliments eſcaped the kidneys undergoes a new trial, throwing off the remainder of its uſeleſs parts in the form

of an invisible *halitus*, sometimes of visible sweat and steam.

6. These then are the three ways bounteous and provident nature has taken to clear the body of its unnecessary foulnesses. And consequently medicines increasing any of those excretions may, and have been in some sort deemed *cathartics* or *cleansers*. But by reason of the more than ordinary putrid foulness of the first kind of excrements, the medicines working that way have had the name of *cathartics* appropriated to them: and an evacuation by stool has been always reckoned the directest method of purifying the whole mass of blood, the putridest and foulest parts being easily separable this way.

7. It is not our business at present to inquire into the original invention of remedies, and their application to the various uses assigned them. It is sufficient to our purpose to observe, that in very ancient times many were actually found out, answering the intentions of the art of healing in promoting the various kinds of evacuations ἰατρικὴ δὲ πασὰ πάλαι ὑπάρχει, καὶ ἀρχὴ καὶ ὁδῷ εὑρημένη, καθ' ἣν καὶ τὰ εὑρημένα πολλὰ

τε και καλως εχοντα ευρησθαι[a]. Some medicines increaſed the cutaneous excretions, ſome were thought to promote the evacuation by urine: but the moſt numerous tribe, and thoſe moſt inſiſted on were the *cathartics* that brought on a copious and more than ordinary expulſion of feculent matter by the *anus*. When they irritated the ſtomach to an excretion upwards, they were called *emetics*, καθαρσικα κατ' ανω.

8. The humours evacuated from the ſtomach and guts are not all uniform or alike. They differ widely one from another both in colour and conſiſtence, and ſo have got different names aſſigned them by the ancients; though they knew little of the animal oeconomy, or of the organs where theſe different humours were prepared, or ſecerned from the reſt of the maſs. Thus the humours of a yellowiſh colour and of ſome moderate lentor in their conſiſtence they called *gall* or *yellow bile*. If they were tough or blackiſh it was *black bile* or *melancholy*. Viſcid, ſlimy and colourleſs liquors were comprehended under the name of *phlegm* or *pituite*. The thinner and ſerous kind they called *water*. And theſe various

[a] Hipp. de Vet. Med. III, 8.

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humours they thought to abound in various proportions in different perſons according to their original frame, their diet, and manner of life, diſeaſes, ſeaſons of the year, *&c.*

9. The medicines then operating this way are not all of an uniform nature: they differ not only in their manner and violence of operation, but alſo according to the humours they ſeem chiefly to evacuate. Hence the ancients, obſerving that, after the adminiſtration of certain purges, the humours excerned out of the body were of a yellowiſh hue, called them *Cholagogues*, or purgers of *gall*. Thoſe, that promoted the expulſion of blackiſh tough liquors, they reckoned *Melanagogues* or purgers of *black bile*. Thoſe that brought on an excretion of ſlimy and pituitous humours they called *Phlemagogues*; as the evacuation of ſerous liquors they ſaid was the effect of *Hydragogue* purges. And accordingly they were extremely ſollicitous to know the ſtate of the body, and which of all theſe humours was in greateſt abundance, and had the largeſt ſhare in the diſeaſe; that they might adjuſt their medicines thereto, and get theſe peccant and ſuperabundant humours expelled out of the ſick per-

perſon. "Atque hæc, ut ego arbitror, "veteres rerum magis eventis moniti, quam "ratione docti probaverunt [a]."

10. Thus far they ſeem to have gone on ſafe enough. Hitherto we ſee nothing more than a careful obſervation of Phænomena; and their claſſing and giving names to things according to their viſible effects and appearances, without determining their real and intrinſic eſſence. But they did not ſtop here: They were not content merely to have obſerved theſe things, but wanted to know the laws and ſprings of the action of bodies upon one another. They were fond of ſeeing, or of thinking they ſaw, the beauty and ſimplicity of nature; and endeavoured to underſtand and explain her various operations by as few general principles as could be. They ſaw many bodies have a mutual tendency of running into contact and coheſion one with another. They ſaw the loadſtone and iron run together without any viſible impelling force. They ſaw threads and ſtraws run to amber as if actuated by an internal principle. They ſaw plants take up the ſap of the earth into their

[a] Cicer. De Divinat. I, 3.

own

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own ſubſtance, each ſeeming to ſuck that which is moſt ſimilar to itſelf; and all this, I ſay, without any viſible impelling force, as far as they could perceive or underſtand the matter. It was but few who gave into *Thales*'s [a] ſcheme of aſcribing ſouls even to the commonly reputed inanimate bodies, and ſuppoſing the world full of minds, τον κοσμον εμψυχον και δαιμονων πληρη; by which ſuch odd and ſurprizing effects might be produced. Nor had thoſe ſimple folks thought of *vortexes* of ſubtile matter [b]; of univerſally pervading elaſtic æthers [c], of harmonies of conſpiring vibrations [d], and other ſuch mechanical, or ſeemingly mechanical explications of the wonderful phænomena of attraction, magnetiſm, and electricity; which the more fertile and ingenious invention of the modern princes in philoſophy has introduced. So that, without troubling their heads about the ſuperior and primary cauſe of ſuch appearances, they reckoned there was an attracting force, whereby thoſe various bodies were drawn, the one to the other, by ſome

[a] Vid. Diog. Laert. I, 24. Ariſtot. de Anim. I, 2. 5. This too was the opinion of Pythagoras (Diog. Laert. VIII, 32.) and of Heraclitus Ibid. IX, 7.

[b] M. Des Cartes. [c] Sir Iſaac Newton.

[d] Dr. Hooke. M. Leibnitz. M. Bernoulli.

ſimilarity

similarity of nature. What are we to expect from all this? They gave such and such medicines to sick persons, and these soon evacuated such and such humours. And streightway they concluded that these medicines taken into the body drew to themselves the humours of a like nature; which *colluvies* must be soon ejected by the expulsive force of the intestines. This is the idea they had of the operation of *Cathartics*, and of their *elective attraction*, whereby they acted chiefly on certain determin'd humours. This their philosophy I cannot say they established sufficiently, though the phænomena that led them into it should be allowed all to be true and fairly represented. It is one thing to make and record an observation carefully and honestly, and another to explain its true causes and its connexion with other things.

11. They were not sufficiently apprised of the quick suscepti on of the *ingesta* into the common mass of blood, and they knew still less of its rapid course from the heart to all the organs and *viscera* of the body. So that going upon their prejudices of the mutual attraction of similar bodies, and of purges

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purges exerting there peculiar forces while lodged in the ſtomach and guts, joined with their vague incoherent ideas of only ſome reptile and undulating motions of the blood; when, going, I ſay, upon theſe ſuppoſitions, they ſaw a little after the adminiſtration of a purge a great evacuation of a certain liquor, what was more natural and obvious for them to think, than that this liquor was forcibly drawn into the guts by ſome ſingular elective attraction of the medicine upon theſe ſimilar parts of the blood; which when ſeparated from the reſt of its compounding elements, and running together, appeared in their genuine form of a true diſtinct humour?

12. We ſee they took it for granted that there actually were in the blood ſuch and ſuch humours they ſaw thrown out of the body. This I ſay they took for granted without ſufficient proof. And accordingly ſuch a previous exiſtence of humours, as well as the elective attraction of medicines on them, has been called in queſtion; and that not ſolely by the moderns. *Eraſiſtratus* had a ſagacious and enterpriſing genius: And *Aſclepiades* was fond of taking up with any thing that contradicted the commonly

received

received medical syſtem. [a] They flatly denied that purging medicines have any attractive forces whereby they might draw ſuch and ſuch humours to themſelves. They ſuppoſed that theſe medicines, when taken into the body, according to their various natures, aſſimilate and corrupt whatever liquors they met with into ſuch and ſuch new forms, and ſo conſtituted the humours which were then evacuated. So that in their hypotheſis the whole effect of a purge ſhould be the altering the nature, and thence leſſening the quantity of the blood.

13. In all this they do not ſeem abſolutely to reject the obſervation of *Hippocrates*. They only differ in their philoſophy, and thence they are led into a fatal miſtake in practice. They do not deny the different operations of medicines as they had been claſſed by the ancients into *Cholagogues*, *Melanagogues*, &c. only what had been formerly aſcribed to an *elective attraction*; they ſeem to aſcribe to an *elective aſ-*

[a] Vid. Galen. de Purg. Facult. 1. 2. De Element. II, 3. De Nat. Facult. I, 13. Cæl. Aurelian. Morb. Chron. III, 5. §. 75. Van Helmont Oper. p. 420, 4. 5. 6.

ſimilating

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similating corruption and *tranſmutation*; the medicine making as it were a new production in the animal, which did not exiſt before. And thence they thought it needleſs to be very careful about what medicine was to be given: ſeeing they reckoned the primary, chief and univerſal effect of Cathartics was to diminiſh the quantity of blood: which they thought might be done for the moſt part in a ſafer and more commodious way, than by giving thoſe medicines. The uſe of which was therefore almoſt univerſally laid aſide by them and their followers of the Methodic ſect. And this hypothetical prejudice *Galen* complains to have had a very bad effect in their management of ſeveral diſeaſes.

14. But if *Galen* was very much diſpleaſed with thoſe innovators in Phyſic, how would it have provoked his indignation, had he lived in theſe later days, to have ſeen his whole Hippocratic ſcheme of *ſpecific purges*, he had taken ſo much pains to embelliſh, quite demoliſh'd, and treated as fictitious and groundleſs by the modern theoriſts? They not only reject the peculiar *attractive forces* of ſuch and ſuch medicines upon ſuch and ſuch humours

of

of the blood; but they do not so much as admit, what the ancients all pretended to observe, that the administration of certain purges commonly procure the evacuation of certain humours. *Thomas Erastus* a very eminent man in our faculty, but still more famous amongst the Divines, Lawyers and Politicians for his schemes of humbling the clergy, broke off from the commonly received doctrines, and resolved all the operation of purging medicines into a *vellicating stimulus*, whereby the stomach and intestines, and the vessels communicating with them, were excited to expel their contents [a]. So that the sole difference of purges was according to their various degrees of force and acrimony; and that therefore they would bring away whatever humours were in greatest plenty, and readiest to be evacuated. Indeed even in *Galen*'s time there were some few, who affirmed all medicines to act equally upon all the humours, with this only difference, that the thinnest and most moveable should come off first, and the rest in order, according to their degrees of fixedness and viscidity [b]. Hence they concluded

[a] De Purg. Facult. 3. p. 183, &c. Epist. Medic. 9. p. 23. [b] Galen. de Purg. Facult. 3.

the

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the weakeſt medicines to be thoſe which purged off water, the next the purgers of gall, then thoſe of pituit and melancholy. But *Eraſtus*[a] and his followers, though led by the ſame theory, concluded in a different way, and claſſed the operation of medicines in a different order. Though they reckoned all purges to bring away firſt and eaſieſt the moſt moveable liquors, yet they found Gall, not Water, to be that humour; as flowing with the greateſt eaſe and plenty into the inteſtines. To purge Water, Pituit and Melancholy a greater force is requiſite; which too always brings gall along with it, though this is leſs minded as being much diluted with the other humours[b]. So that *Pechlin*[c], treading *Eraſtus*'s footſteps, would claſs purging medicines into a new way according to their degrees of ſtrength and acrimony. Under the milder purges he would comprehend the ordinary *cholagogues*; the ſharper kind take in the purgers of *pituite*, and the rougheſt of all thoſe which were able by their great acrimony to ſet the

[a] De Purgant. Facult. 3. p. 185. [b] Ibid. p. 184. 185. 186. Vid. & Pechlin. de Purgant. 25. p. 342. 345. 346. 347. 354. 355. [c] Ibid. p. 339, 340. 343. 344. 345. 355.

black

black bile and ſtagnating *waters* agoing. However they both affirm in general, and for a proof appeal to experience, that all the ordinary purges of whatever denomination may and do ſometimes evacuate all the various humours, as they happen to be eaſieſt moved [a].

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Van Helmont [b] indeed went farther than any body. He loudly pronounced all the Galenic phyſicians impoſtors; and their *Cathartic medicines* he look'd on not as having any virtue of cleanſing the blood of its impurities, but as poiſonous corrupters and deſtroyers of the ſubſtance of the blood and fleſh of animals. This was dealing in whole ſale; it was condemning phyſicians and their remedies by the lump.

15. Few have choſen to carry matters ſo high as this great chemical and impetuous reformer of medicine. Nay *Eraſtus*'s ſcheme was not much followed for ſome time. But about the middle of the laſt century, when the circulation of the blood

[a] Eraſt. Ibid. p. 192. Pechlin. Ibid. p. 342. 344. 346. 347. 348. 349. 350. 351. [b] De Febr. 5. in Oper. p. 755, &c. & Oper. p. 256, 7. p. 420. 4. 5. 6. 7.

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gave new light into phyſic, and people ſeemed very prone to find fault with the ancients, there was a great run againſt the Hippocratic ſyſtem of humours, and *elective operation* of purges. Thus Dr. *Ent* [a] the great champion of the new doctrine, diſcarding the ſimilar attractions of bodies, affirms that purging is effected by the irritation of the veſſels, whereby the redundant and noxious humours are expelled. "Adeo-"que purgatio dici merito queat *vaſorum* "*vomitus*."

The great *Malpighi* [b], in his early attempts to reform the medical phiſiology, gave into the ſame thought preciſely: for, rejecting the elective attraction of purges, he aſcribed all to an acrid *ſtimulus*, irritating and inlarging the orifices of the veſſels. And this he had, it ſeems, ſupported with ſuch plauſible arguments, that he has *Borelli* [c] very readily aſſenting to that new ſcheme. And ſo too the great fame and authority of Dr. *Willis* [d] might contribute not a little to the rejecting the ancient ſyſtem of *elective*

[a] Apolog. pro Circ. Sang. p. 57.
[b] Vit. Poſth. p. 3. 22. [c] Vid. Malpigh. Ibid. p. 3. 251
[d] Pharm. Rat. I. Sect. II, 1. §. 29. p. 26. Sect. III, 1. §. 16. p. 46, &c.

purges:

purges: which *Pechlin* [a] has with the greatest keenneſs of all endeavoured to overturn.

16. They eaſily ſaw that the hypotheſis of the *elective attraction* of medicines was very arbitrary and precarious in itſelf, and but ill ſupported by its greateſt advocates. And yet their objections were rather like cavils than ſolid and true confutations. *Bellini* took a juſter and more regular way of arguing againſt them [b]. He very modeſtly allows *attractive forces*, or ſomething like them, not to be things ſo abſurd or uncommon in nature, as to deſerve the ridicule they had ſometimes met with: but at the ſame time he evidently ſhews with how little reaſon the general doctrine of *attraction* is applied to medicines, and gives us very ſtrong arguments againſt their having, or exerting any ſuch properties on humours at a diſtance, as uſed to be aſcribed to them.

17. The moderns then did not only reject this philoſophical explication of the

[a] De Purgant. 25. p. 328, &c.
[b] De Miſſ. Sang. p. 209, &c.

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action of Cathartics (*Eraſiſtratus* and *Aſclepiades* had done as much before) but they went farther, and even denied the *elective operation* itſelf of ſuch and ſuch medicines, bringing away ſuch and ſuch humours, and reſolving all their effect into a weaker or ſtronger *ſtimulus*, affirmed all purges to bring away all humours indifferently, as they happened to be in readineſs to yield to the irritating force. And reckoned [a] that the ancients were impoſed upon by the colours of the excrements, which were tinctured variouſly by the medicines; and thence appeared under the form of ſuch and ſuch humours. Thus ſay they the inteſtinal liquors look like Gall when tinctured yellow with Aloes or Rhubarb; and like Black Bile when infected with the auſtere tincture of Polypody, Senna or vitriolic bodies, *&c.* whence medicines got the titles of *Cholagogues*, *Melanagogues*, &c.

18. All this looks very plauſible: and moreover they adduce experiments to confirm their aſſertion, that medicines purge humours indiſcriminately, and of other claſſes,

[a] Vid Eraſt. Ibid. p. 186. Ent. Ibid. p. 57. Willis Ibid. p. 26. 46. 48. Bellin. Ibid. p. 231.

than those to which they are ascribed. [a] *Erastus* says he scarcely ever saw purges work without bringing away a good deal of gall. [b] Yet he often found *cholagogues* to purge more pituite than gall itself. [c] He saw physic which should have purged only gall and pituite bring away very black stuff. Manna is considered chiefly as a *Cholagogue*, and yet given in a decoction of chiches he has seen it [d] purge off a great deal of water tinged with gall, sometimes only very black liquors. Rhubarb too is a famous *cholagogue*, and in consequence of that prepossession *Massaria* [e] and *Septalius* [f] would dissuade the use of it in dropsical diseases. Yet *Erastus* [g] observes that some of the best practitioners [h] have given it with success in drawing off the water in dropsies. He himself [i] has seen it bring away a great deal of black humour like ink. And the same effect he tells us [k] of Aloes made into pills. [l] Hellebore is chiefly recommended in those

[a] Ibid. p. 186. [b] Ibid. p. 189. [c] Ibid. p. 186.
[d] Ibid. p. 186. 192. [e] Pract. III, 16.
[f] Apud Bonet. Labyr. Med. VIII, 163.
[g] Ibid. p. 192. Epist. Med. 9. p. 24.
[h] Vide & Holler. de Morb. Intern. I, 39. River. Prax. VI, 6. [i] De Purg. Facult. 3. p. 192.
[k] Ibid. [l] Vid. Cels. Med. II, 12. p. 84, 32.

ESSAY II. caſes wherein the atrabiliary humours are ſaid to prevail; nevertheleſs he [a] often obſerved it, when given even in tumours of the ſpleen, to bring away nothing but a tough yellow pituite, and ſo to have put the patient in a good way. Sometimes he [b] has ſeen it purge a great deal of watery and ſlimy ſtuff, and a very little of yellow bile. And I remember Dr. *Freind* [c] tells us of the wonderful effect of the black Hellebore in dropſies, but then he ſpeaks of it as a *diuretic*.

19. Were the operation of all the various Cathartics as indefinite as *Eraſtus* would make us believe, we might indeed with ſafety reject their *elective* or particular influences, and equally expect an evacuation of one humour as of another by any of the purging medicines, according to its degree of acrimony, whereby it is enabled to irritate the veſſels and inteſtines, and make them expel their contents. Shall we then abſolutely condemn the obſervations of the ancients, or rather the accounts they gave of their obſervations. If the various hu-

[a] Eraſt. Ibid. p. 186. [b] Ibid. p. 192.
[c] Hiſt. of Phyſ. II. p. 105.

mours

mours are to be moved indifferently by any purges, they were either very careleſs obſervers, or very diſhoneſt relaters of fact, when they ſo unanimouſly tell us of ſome medicines evacuating one kind of humours, and others another ſort. This but ill ſuits with the ordinary character of the old writers in Phyſic, who are otherwiſe remarkably famous for their extraordinary ſkill and attention in obſerving, and their ingenuity and correctneſs in deſcribing the appearances of nature. Indeed they do not ſay that purges of a given claſs and denomination do ſolely expel their correſponding humour: they affirm that they chiefly exert their force upon it, acting however upon the others, though in a ſmaller degree.

Thus *Hippocrates*[a], though he affirms that upon giving a medicine that works upon Phlegm, Phlegm ſhall be evacuated; that a medicine working upon Gall ſhall bring away Gall, that in like manner you ſhall bring away Black Bile by adminiſtring a medicine that naturally works upon it; and that at any time by night or by day, in winter or ſummer, while the perſon continues in life: though, I ſay, *Hippocrates* tells us all

[a] De Nat. Hum. VIII, 11.

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this, yet he [a] informs us at the same time, that the purgers of Gall first indeed purge pure Gall, and then Gall mixed with other liquors; and purgers of Phlegm first bring away the purest Phlegm, and afterwards mixed, &c. Το γαρ φαρμακον——ωρῶ̃ου μεν αγει ὁ αν αὐ̃εω καῖα φυσιν μάλιϛα η των εν τω σώμαῖι ενεοντων, επειῖα δι και τ' αλλα ἐλκει τε και καθαιρει [b]. All which is very contrary to the abovementioned scheme of some whom *Galen* [c] had to do with, and of *Eraſtus* and *Pechlin* in later times; whose theory *Galen* shews to agree very ill with daily experience; whereby, instead of the humours coming away by all medicines whatsoever, if strong enough, in a certain order; as first (Water or) Gall, then Pituite, then Melancholy; they come off, as *Hippocrates* observed, according to the peculiar faculty of the medicine that was given; so as even Phlegm, or Black Bile does appear first, if a *phlegmagogue* or an *atrabiliary* purge be administred; and then may follow other humours according to the nature of the cathartic, and the state of the person to whom it is applied.

[a] Ibid. X, XI. [b] Ibid. X, 6.
[c] De Purg. Facult. 3.

20. But

20. But ſtill the tincture or colouring of the medicine has little to do in this caſe; though this, as we formerly [a] had occaſion to obſerve, is commonly given out as the fundamental error of the ancients, and what led them into their miſtaken ſyſtem of *elective* purges. No body would expect a deeper yellow in ſome pounds of the excrementitious liquors from a few grains of the grey inſpiſſated juice of the Syrian *Convolvulus*, than from a like quantity of the bitter apple or of the juice of the wild cucumber. And yet Scammony is a *cholagogue*, and Elaterium and Colocynth are ſtrong *hydragogue* purges: as is alſo the yellow gummous drug we have from the *Indies*; which ſhould rather have been claſſed with the purgers of Gall, if the real effect of the medicine had not been more minded than the colour of its tincture. The reſin and extracts of Hellebore and other Cathartic roots, though differing in colour, have the ſame virtue as the roots themſelves. [b] Nor do the metallic ſalts, not even the vitriol of iron itſelf, tinge animal fluids of a black colour, except there be an additional mixture of ſome aſtringent

[a] Vid. §. 17. [b] Pechlin. de Purg. 3. p. 40, &c.

vegetable.

ESSAY II. vegetable. And the copper minerals and recrements, as *lapis Lazuli*, *Armenus*, *ſquama aeris* &c. are not only *melanagogues*, but ſtrong water-purges; and particularly recommended in dropſical diſeaſes[a].

21. So indeed in *Hippocrates*'s ſcheme we may expect that, if at any time you give a purging medicine to a perſon, who has but little of its principally correſponding humour, it muſt exert its force the more in bringing away ſome others, that happen to be in greateſt plenty, or eaſieſt moved. Which will the oftener happen that the effect of many purges, as the ancients themſelves have very well obſerved, is not ſolely confined to one kind of humour. Thus Rhubarb and Scammony, beſide their evacuating Gall, are allowed to have conſiderable influence in purging *Pituite*. And black Hellebore, though by ſome ſpoke of as only an *atrabiliary* purge, is by the ancients commonly ſaid to evacuate Gall and Pituitous Humours[b].

[a] Liſter de Hydrop. p. 53. &c.
[b] Dioſcorid. Mat. Med. IV, 146. Plin. Nat. Hiſt. XXIV, 5. &c. Oribaſ. Collect. VII, 27.

Even

Even in the old lists of cathartic medicines [a] left us by *Ruffus* and *Oribasius*, &c. there are scarcely any that are not said to purge more than one humour. And they had their *panchymagogues* too both simples and compositions. But Chemistry has furnished us with still more universal medicines. We have mineral preparations not evacuating solely the intestinal humours. Some there are that not only set one a vomiting and purging various liquors; but increase perspiration, raise a sweat, bring on a salivation and what not.

22. That most curious and faithful Anatomist *De Graaf* has a notable instance, serving to shew not only the *elective* action of purges on their proper corresponding humours, but also their additional force upon some others. "Inter ea," says he [b], "quæ "succum Pancreaticum per alvum educunt, "conveniunt, præ cæteris, medicamenta "hydragoga, quorum beneficio serosi humores magis quam bilioſi expurgantur: "quod ante aliquot annos observavimus

[a] See Oribas. Collect. VII, 27. Synops. I, 17. Act. Tetrab. III, 24. —— 55. Paul de Re Med. VII, 4.

[b] De Succ. Pancreat. 10. Oper. p. 621.

"in

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" in canibus non paucis, quibus tam hydra-
" goga quam cholagoga purgantia exhibue-
" ramus. Et quidem hac ratione exhibito
" purgante, cum jam alvum egregie depo-
" nerent, viventibus adhuc canibus, ipso
" purgationis tempore, subito abdomen
" aperuimus, quo peracto haud difficulter
" observare potuimus in illis, quibus medi-
" camentum cholagogum v. g. diagrydij
" drachmam exhibueramus, bilem longe
" majori copia effluere e ductu bilario in-
" testinali; in alio vero cui hydragogum
" v. g. pulv. radicum jalappæ drachmas
" duas exhibueramus, animadvertimus suc-
" cum pancreaticum majori copia per ductum
" suum in intestina erumpere, licet tunc
" bilis quoque majore copia prodiret; & in
" alio, cui cholagogum porrexeramus, suc-
" cus pancreaticus etiam solito majore copia
" emanaret; colligere tamen potuimus a
" cholagogis bilem, & ab hydragogis suc-
" cum pancreaticum longe copiosius ex-
" purgari." Thus far *De Graaf.* And when *Pechlin*[a] denies these experiments, or the force of them in supporting the scheme of *specific* purges, and hints at experiments of a quite contrary tendency, we

[a] De Purg. 5. p. 352.

can

can only wish he had been more explicite and full upon such a material article; or else be at the pains, when we have leisure and opportunity, to repeat them ourselves, to illustrate the operation of cathartic medicines.

23. In the mean time what *De Graaf* pretended to find by anatomical experiments, agreeing exactly with the ordinary medical practice in all ages, is supported by the common method of carrying on evacuations in the cure of diseases, and adjusting medicines to the humours they were designed to expell. In this respect the ancients seem to have been very sollicitous about the state of their patient, and the nature of his malady before they administered their purges. They gave *cholagogues* to those whom they conceived to be oppressed with Gall, *phlegmagogues* to those they thought had too much Pituite, *water-purges* to the dropsical, and the purgers of *black-bile* to those in whom the *melancholia* seemed to be any way peccant. It is from *Hippocrates* [a] himself, or the old Hippocratic writings all this is taken. And he gives us fair warning that if we do otherwise we shall find ourselves disappointed

[a] De Purg. II. De Nat. Hum. XVII, 8.

in

ESSAY II. in our intended cure, bringing away indeed some humours, yet in a troublesom and painful way, and but little of those our patient wanted to get rid of.

Galen [a] appeal'd to his own daily and public practice at *Rome*; and to the observations even of those, who, without regarding *Hippocrates*, founded their practice on common experience. He bids his adversaries bring him a patient labouring of the Jaundice, his body all over yellow, and steeped, as it were, in gall, and he would undertake, after a few days preparation, to restore him to his wonted good looks by a *cholagogue* purge. He tells us this is not empty boasting; he had done it not once or twice, but often and again, and by so doing had reclaimed many from their erroneous way of thinking. If medicines act only by altering the texture, and thence evacuating a part of the mass, as the followers of *Asclepiades* contended, he bids them try their hand on the cure of a Jaundice. Let them in consequence of their theory take some blood from the patient, or bring him low by abstinence, or give him an ordinary

[a] De Purg. Medicam. Facult. 2. Confer. & de Elem. II, 3: De Natur. Facult. I, 13. De Atra Bile 9.

melanagogue

melanagogue purge, and they will grow wiſer by misfortunes. Juſt ſo, ſays he, take a patient labouring in a Dropſy, and you will find a vaſt odds between opening a vein, and giving him a *water-purge*. But had you given him phyſic appropriated merely for purging Yellow or Black Bile, you ſhould not by that have brought down his belly.

24. Yea the method even of the moderns in the preſent age agrees with that of *Galen*. You would think that when they come to practice they had laid aſide their hypotheſis of a general indiſcriminate purging *ſtimulus*. Thus *Eraſtus* [a] himſelf: "Ita a cæteris "diſſentio, ut interea idem cum omnibus "agam. Nam quoties morbus a pituito- "ſis vel bilioſis humoribus ortus fuerit, ac "purgatione in ejus curatione opus eſt, pur- "gantibus utor talibus, quæ peculiari vir- "tute pituitam, vel bilem detrahere vulgo "dicuntur, & creduntur.

"Advertendum, ſays *Van Helmont* [b], "quod impie *cholagoga* cathartica propina- "rint hydropicis. *Hydragogum* autem dif-

[a] De Purg. Facult. 1. p. 131.
[b] Oper. p. 416, 38.

ESSAY II.

"fert a *cholagogo*: quod illo epoto venter "detumeſcat, nec fœtida excernat." Thus we find a ſworn enemy to *Galen* and all his doctrines unwittingly falling in with a part of his practice, and zealouſly maintaining the peculiar faculty of medicines in carrying off their correſpondent humours; drawn thither it would ſeem, not, we may be ſure, by authority, but by the force of experience and the obſervation of facts. Is not the ordinary Jaundice, ariſing from an obſtruction of the biliary ducts, very commonly cured (notwithſtanding the contrary advice of *Cælius Aurelianus* [a]) by giving Aloetic and Scammony purges (both noted *cholagogues*) joined with proper deobſtruents? And the common purges ſtill uſed in Dropſies are the inſpiſſated juice of the wild Cucumber, the juice of the Iris root, Elder bark, Syrup of Buckthorn, and others of the *Hydragogue* tribe, aſſiſted with Diuretics and corroborating medicines. And although we have an ordinary way of blending ſeveral purgatives together in ſuch caſes, yet the chief ſtreſs is commonly laid upon thoſe, which the *Galeniſts* themſelves would have thought peculiarly adjuſted for that purpoſe.

[a] Chron. III, 5. §. 75.

Not

Not that the reſt are all uſeleſs; for, as we have already had occaſion to obſerve, the ordinary purgatives have ſome influence on the other humours beſide thoſe, from which they have got a peculiar denomination.

25. Indeed though it ſhould be granted, that the whole virtue of Cathartics lay in their ſtimulating force, and confined to their action on the *primæ viæ*, their operation would not, for all that, be ſo uniform, and equally indifferent to all humours whatever, as ſome people ſeem to expect from ſuch a property. *Eraſtus* himſelf does not deny that medicines by their ſtimulating power may variouſly affect the excretion of humours. "Quod ſi quis," ſays he[a], "mallit cauſam cur alia medicamenta bilem "flavam, alia nigram, alia pituitam, alia "aquam vel ſerum educere videantur, ad "occultam poteſtatem referre, haud me "præbebo difficilem, modo non aſcribat po-"tentiæ per electionem tractrici. Non "enim inficior pharmaca *pro ſuæ temperatu-"ræ diverſitate diverſe virtutem expultricem "incitare ac vellicare.*" What are the various Taſtes but the various *ſtimuli* on the

[a] De Purg. Facult. 3. p. 191.

ESSAY II. nervous *papillæ* of the Tongue? We may presume they differ one from another in many particulars beſide their ſtrength of irritation. So too the various Smells are but various ways of ſtimulating the nerves of the olfactory membrane, various, I mean, both in their method of irritating, and degrees of force. Juſt ſo in very many reſpects may the ſtimulating powers of Cathartics be ſuppoſed to vary from one another. *Bellini*[a] gives us a fine ſketch of this matter, when he tells us; "In medicamentis cum ſtimulo conjunctis per diverſa medicamenta diverſi humores extra corpus derivari poterunt abſque eo quod eadem ad humores pertingant; medicamenta enim illa, utpote diverſa, diverſimode communicabunt impetum corporibus penetrantibus, vel diverſimode ſtimulabunt; & diverſitas ſtimuli ſatis erit, cum & ipſa nihil aliud ſit quam diverſitas impetus, quæ diverſo modo nitatur oportet in ea, quibus ad contactum ponitur (quæ ex doctrina fermentorum[b] clarius) & tota res experientiæ erit, qua didicimus per medicamentum tanti impetus, aut tanti ſtimuli,

[a] De Miſſ. Sang. p. 208.
[b] Vid. Opuſc. ad Pitcarn. p. 168.

"hunc

" hunc aut alium humorem ſecerni, cum " de hujuſmodi humorum cohæſione, & " applicatione apti momenti nihil per ſcien- " tiam ſciri poſſit." Upon this, without having recourſe to the precarious philoſophy of *elective attractions*, we ſee there might be founded a very rational explication of the *elective operation* of Cathartics upon their reſpective humours they are obſerved to bring away; though the whole virtue of theſe medicines ſhould be ſuppoſed to lie in their ſtimulating force, and their immediate application confined to the *primæ viæ*.

26. But in reality they are not confined to the ſtomach and guts; they reach to the blood itſelf; and along with it pervade all the members and *viſcera* in the body. This opens a new field of action for them, little attended to by the ancients; wherein they may diſplay their numberleſs virtues and powers of operating on the blood, and the various organs of ſecretion; and thence, according to their different natures, evacuate the different humours we deſign to have expelled.

That, beſide the irritating force of purges upon the *primæ viæ*, they are taken into the

ESSAY II. blood itſelf has been abundantly demonſtrated from many obvious conſiderations [a]. We find ſome of them diſcover their actual preſence in the blood by their colour and ſmell in the urine [b]. The ſame is evinced by the common obſervation of a child being purged by the milk of its nurſe under phyſic [c]. *Melampus* is famous in ancient [d] ſtory for curing the daughters of King *Proetus* of their Madneſs by purging them with the milk of Goats feeding upon Hellebore. From which and many other conſiderations we are to conceive medicines to be taken up into the blood by the abſorbing veſſels of the *primæ viæ*, and thence to be propelled through all the courſe of circulation.

27. Moreover their influence on the blood, and the various ſecretory organs, independent of their action on the ſtomach and inteſtines, is fully eſtabliſhed by their manifeſt effects on the body, without their immediate application to theſe *viſcera*. Every body is appriſed of *Hippocrates*'s [e] axiom,

[a] Bellin. Ibid. p. 201. &c.
[b] Willis Pharm. Rat. I. Sect. III, 1. §. 14. p. 45.
[c] Hipp. IV. Epid. V, 51. Willis Ibid.
[d] Plin. Nat. Hiſt. XXV, 5. Galen. de Atr. Bile. 7.
[e] VI. Epid. VI, 2.

εκπνοον και εισπνοον ὁλον το σωμα. Many instances there are of the effectual cathartic operation of invisible steams [a]. We have numberless observations of medicines externally applied to the body, and insinuating themselves into the blood, so as to bring on evacuations as successfully, as if given by the mouth [b]. I have myself procured a Looseness for some days by the application of a plaster, when the patient's obstinate wilfulness, or natural squeamishness could not bear the swallowing of drugs. And oftener than once I have known people set a vomiting by a lotion of the head [c]. Some time after the invention of the circulation some ingenious physicians bethought themselves of injecting medicines directly into the veins, so as to mix them with the blood without going the long round of the *primæ viæ*, *&c.* But though this practice was soon laid aside, we have instances upon record [d] of purges thus

[a] Vid. Erast. de Medicam. Propr. 56. p. 102. 60. p. 112. 113. De Purg. Facult. 2. p. 176. Pechlin. de Purg. 10. p. 115. Boyle Useful. of Experim. Philosoph. Abr. I. p. 89. Of Effluv. Abr. Ibid. p. 416.

[b] See Oribas. Synops. IX, 23. 24. Collect. VIII, 47. p. 364. D. Harv. De Mot. Cord. &c. 16. p. 61.

[c] Vid. & Willis Pharm. Rat. I. Sect. II, 1. §. 28. p. 26.

[d] Phil. Trans. Abr. III. p. 234. Boyle Usef. of Exp. Phil. Abr. I. p. 38. Etmuller Chirurg. Infusor. I, 4. 5.

ESSAY II. conveyed into the blood operating in the same manner, as if they had been taken in the natural way by the mouth. What is the result of all this, but that medicines may so work upon the blood and the several secretory *viscera*, as to procure an extraordinary separation & expulsion of certain humours out of the body, without considering these purges as acting immediately on the stomach and intestines? And of this the more considerate of the moderns seem to be sufficiently sensible, when they tell us [a] that Cathartics, as well as other medicines, bring the blood into various ferments, that is, to speak intelligibly [b], bring its particles into various motions and modes of cohesion, and thence dispose it to undergo various secretions, and to exhibit the several humours we commonly observe to be excerned.

28. "Hoc sum contentus, quod, etiamsi "quo modo quidque fiat ignorem, quid "fiat intelligo [c]." What though we should

[a] See Malpigh. Vit. Posth. p. 3. Willis. Ibid. Sect. III, 1. §. 16. p. 47.

[b] See Bellin. de Miss. Sang. p. 199. 200. 204. 205. 206. 207. 208. 215. 216. 218. 219. 220. Chyene Theor. of Fev. p. 98.

[c] Cicer. de Divin. I, 9.

not

not pretend to explain the various inviſible Operations of Medicines upon the ſolids and fluids of the body; how they may alter the motions of their particles, their modes of coheſion *&c.?* "Non reperio cauſſam "latet fortaſſe obſcuritate involuta naturæ[a]." Sure we are of their viſible effects; which we are principally concerned with in the practice of phyſic: their real manner of acting being a queſtion more of a philoſophical than medical nature. Now by the taſte itſelf we diſcover a variety of action of various medicines; ſome affecting one part, ſome another part of the mouth more than others. "Ita Helleborus Albus Labia (ob- "ſervante D^re^ Grew) Colocynthis linguæ "medium, Solanum lethale Palatum, & "Jalapium gulam maxime (& præ aliis "guſtus organis) afficere ſolent[b]." And then, which is more to our purpoſe, conſidering them as carried farther into the body, and circulating along with the maſs of blood, we know that ſome medicines diſpoſe the body to a more than ordinary evacuation by the ſkin in the form of Sweat and Perſpiration; ſome favour the excretion by Urine,

[a] Cicer. Ibid. 18.
[b] Fuller Pharm. Exemp. Decoct. Cort. Jugl.

ESSAY II.

ſome promote an evacuation by Slaver from the common ſalivary glands. So that we ſhall not think it ſtrange if by ſimilar methods ſome ſhould ſo affect the liver, and the blood paſſing through it, as to produce a more than ordinary evacuation of gall; others an extraordinary ſecretion of pancreatic lymph, and of the other thin liquors poured into the inteſtinal tube; whereas others may promote a ſecretion, or at leaſt an extraordinary expulſion of the mucous pituite, furniſhed by the glands of the ſtomach and guts which line their internal cavity: nor is it impoſſible that ſome may diſpoſe and aſſiſt the blood to depoſite upon theſe emunctories its groſſer, black and more earthy feculent particles. So that, though *cholagogues*, *hydragogues*, *phlegmagogues* and *melanagogues* do all bring their reſpective humours into the common ſink of the body, and are all expelled thence by the ſame outlet; yet it is as eaſy and natural to conceive the various actions of theſe medicines on the blood and ſecretory organs, as of *diaphoretics*, *diuretics*, *ſialagogues*, &c. which carry off their reſpective humours by ſo many diſtinct and independent paſſages.

29. The

29. The truth of such a distinction among the common Cathartic medicines, according to their effects in purging various humours, is a mere question of fact, and must be determined by observation. We have seen the ancients full and explicit enough in this point: and we found the common medical practice favouring very much, and supporting their system. Most of the moderns indeed are very shy, and would fain persuade themselves into an uniformity of action of these medicines. They are at a great deal of pains in endeavouring to resolve their whole effect into a simple irritation of the vessels, or into a fermenting and attenuating quality, by which they dissolve all the cohesions of the particles of the blood, and so set the humours at liberty to pass through their proper glands. In these hypotheses, either of an uniform *stimulus*, or of an uniform universally dissolving ferment, every evacuating medicine would, as Dr. *Keill*[a] well observes, equally and indifferently increase the quantity of every secretion: Mercury would as constantly purge as salivate; and Nitre promote

[a] Eff. IV. p. 164. 165. 168. 169.

Perspiration

ESSAY II.

Perſpiration as well as Urine; and Aloes or Jalap ſhould not ſolely increaſe the evacuation by ſtool. But this is repugnant to experience; by which we find the various evacuating medicines commonly operate, when regularly managed, in a certain determinate way, without much affecting the other ſecretions. Whether they work by ſtimulating the ſolids, or ſuperinducing certain changes or fermentations in the fluids, or in ſome meaſure by both theſe ways, as it is probable in moſt caſes, certain it is that theſe operations muſt be performed in very different manners, to produce ſuch a multiplicity of appearances, and ſecretions from the blood. And as we find the Saliva, Sweat, *&c.* to require different appropriated medicines to augment their ſecretion, juſt ſo may the different alvinar humours, as Gall, Pancreatic liquor, Gaſtric and Inteſtinal Lymph, Slime, *&c.* ſeem to require different *ſpecific purgatives*, to carry them off through their proper glands to the cavity of the inteſtines, and thence to be thrown out of the body by the *anus*.

30. Now then as reaſon gives us ground to expect a variety of the influence of medi-

cines

cines on the blood, and on the ſeveral organs of ſecretion, which ſend forth their liquors by this common outlet, ſo we find in reality that, even in the later days, different purges are allowed to evacuate the different humours, that are carried off in the alvinar excretions. *Eraſtus* himſelf is modeſt enough when things are ſtated in this view. "Non nego" (ſays he[a]) "partem pharmaci per venas meſenterii penetrare aliquouſque, & humores, qui ibi ſunt, incidere, ſeparare, extergere, colliquare, denique a natura repelli ad inteſtina, una cum humoribus colliquatis & exterſis; quos loco ſuo movere alias natura non potuiſſet. Quod ſi in hac re diſcrimen pharmacorum, & præterea cauſam, cur non omnia quemvis ſemper humorem purgent, quærendam aliquis putet, cum eo non valde contenderim. Quamquam video tam brevi ea tempore, poſtquam ſumpta ſunt, alvum turbare, ut nihil hic operæ precii facere potuiſſe videantur." Thus far *Eraſtus*. And what he allowed to have ſome ſhew of probability, though, in theſe days (not underſtanding the quick abſorption

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[a] De Purg. Facult. 3. p. 186.

and

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and distribution of the *ingesta*) he could not give into it, seems to make a great part of some of the most approved modern systems. Thus *Willis*[a]: "In quantum pharmaca "particulis diversi generis prædita variis mo- "dis cum sanguine, aliisque succis fermen- "tescunt, propterea dejectiones modo se- "rosæ, modo biliosæ, aut alterius indolis "succedunt. Etenim nonnulla, uti impri- "mis Aloe, ac Rhabarbarum, quia, &c.— "cumque hac ratione bilis copiosius aggesta "e receptaculis suis in intestina exundat, "dejectiones plus biliosæ evadunt. Porro "alia cathartica, uti Jalapium, Colocynthis, "Elaterium, & quædam Mercurii præpara- "ta, particulis acrioribus, & non raro quasi "septicis constant: quæ propterea ab in- "testinis suscepta, indeque sanguini trans- "missa, massam ejus insigniter fundunt, & "in serositatem valde præcipitant. Dein "siquidem eodem tempore, quo sanguis "funditur, vellicatio in intestinis habetur, "cruoris recrementa serosa, ejusque cor- "ruptelæ & liquamina, ex arteriarum oscu- "lis ibidem reseratis in viscerum istorum "cavitates exspuuntur; adeoque dejectiones

[a] Pharm. Rat. I. Sect. III, 1. §. 16. p. 47.

"plurimum

" plurimum aquoſæ inducuntur." Let us lay aſide the Chemical and other terms which have little meaning in the preſent queſtion, and take preciſely what is real in all this, and what downright experience and the reaſon of things has forced the oppoſers themſelves of the ancients to inculcate upon us; and then we ſhall find that they, drawn in by truth itſelf, have fallen, without thinking of it, into the unjuſtly exploded doctrine of *Elective purges.*

31. From all which I hope I may be allowed to recommend this old doctrine to a more favourable hearing than it uſes to meet with, and to the ſerious conſideration of the phyſicians of the preſent age, ſo juſtly fond of copying out truth and nature: and that in their giving Cathartics, and obſerving their effects on human bodies, they would carefully remark wherein and how far ſuch medicines may really differ from one another. It is true the mind of man is very limited and imperfect; and men have arrived at their preſent knowledge of things very gradually and by ſlow ſteps. But it muſt be allowed that the ancient phyſicians, though they knew not much of the Phyſiology of the Body,

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were nevertheleſs very careful obſervers of the *phænomena* of Nature they thought themſelves principally intereſted in, and very exact and honeſt recorders of the ſame: and ſeldom went wrong when their light and notices of things could poſſibly keep them in the right path.

ESSAY

ESSAY

ON THE

Conſtruction and Graduation

OF

THERMOMETERS.

Qui vel caloris vires, & calorem ipſum veluti in gradus partiri, vel materiæ cui inditus eſt copiam quantitatemque diſtincte percipere, &c.——Utinam id alii & perſpicaciori præditi ingenio, & quibus in ſumma tranquillitate rerum naturam perſcrutari licuerit aſſequantur; ut homines non omnium modo ſcientes, ſed omnium fere potentes fiant.

Bernardinus Teleſius.

St. *Andrew's, Aug.* 1738.

SOME OBSERVATIONS AND REFLECTIONS Concerning the Conſtruction and Graduation OF THERMOMETERS.

ESSAY III.

WE cannot enough commend and admire that excellent invention of *Thermometers*, whereby we are enabled to make ſome judgment of the various degrees of heat in bodies. It is not our buſineſs at preſent to determine to whom we owe that noble and uſeful diſcovery: whether to *Sanctorio*, to *Galileo*, to Father *Paul*, or to

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Drebbel. For I find it aſcribed to all theſe by their reſpective favourers and admirers [a]. At firſt, as is the fate of all other inventions, Thermometers were but rude and imperfect machines, and not eaſily to be applied to ſo many purpoſes as came afterwards to be in uſe. They were very clumſy: and as the various degrees of heat were pointed by the different contraction or expanſion of air, they came afterwards to be found uncertain, and ſometimes deceiving meaſures of heat;

[a] The invention is given to Drebbel by his countrymen Boerhaave (Chem. I. p. 152. 156.) and Muſſchenbroek (Tent. Exp. Acad. Cim. Add. p. 8. Eff. de Phyſ. §. 946.) Fulgenzio (Life of Father Paul p. m. 158.) aſcribes it to his maſter Father Paul Sarpi, that great oracle of the Republic of Venice. But there was an humour prevailed in thoſe days of fathering almoſt all the curious diſcoveries of the age on that great ſtateſman and virtuoſo. Vincenzio Viviani (Vit. de l' Galil. p. 67. See too Oper. di Galil. Pref. p. 47.) ſpeaks of Galileo as the inventor of Thermometers. But we know how much and how fondly he adored the memory of his great maſter. (See Hiſt. Acad. des Scienc. 1703. p. 169. 175. 176. 180.) Still all theſe are poſthumous claims, and they too imputed by others. But Sanctorio himſelf (Com. in Galen. Art. Med. p. 736. 842. Com. in Avicen. Can. Fen. I. p. 22. 78. 219.) expreſly aſſumes the invention in queſtion. And Borelli (De Mot. Animal. II. Prop. 175.) and Malpighi (Oper. Poſth. p. 30.) aſcribe it to him without reſerve. And theſe Florentin Academicians are not to be ſuſpected of partiality in favour of one of the Patavinian ſchool.

as

as the bulk of air was affected not only by the difference of heat, but likewise by the difference of weight of the atmosphere [a].

2. [b] *Ferdinand* II. great Duke of *Tuscany*, or the gentlemen of the *Academia de l' Cimento* under his protection, made a very great improvement on those curious and useful machines. They made them with Spirits inclosed in glass tubes, and these hermetically sealed. So that they could suffer nothing by the evaporation of liquor, or the various gravity of the incumbent atmosphere. And it was Thermometers made in this way which were first introduced into *England* by Mr. *Boyle* [c], and came immediately to be of universal use among the virtuosi in all the several countries, wherever polite learning and philosophy were cultivated.

3. But there was not so much use made of those instruments as they were capable of. We have plenty of observations made with particular thermometers at different times and places. But then these were not con-

[a] Boyle Exp. on Cold. Abr. I, p. 577. &c.
[b] Vivian. Vit. de l' Galil. p. 67.
[c] Exp. on Cold. Abr. I, p. 582.

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ſtructed by any fixed ſcale or ſtandard. Even the *Florentin* Weatherglaſſes themſelves, whoſe higheſt term was adjuſted to the great ſun-ſhine heats of that country, were too vague and indetermined. And in other places every workman made them according to his own way and fancy; without adjuſting his numbers to any known or determined degrees of heat. And ſo they could not be compared one with another; nor could the obſervations made by different perſons, and in different parts of the world, be collated with any degree of certainty or juſtneſs. By which means, notwithſtanding all the very numerous regiſters of the weather that have been kept and publiſhed by different authors, we are ſtill at a loſs to determine the comparative differences of heat and cold in different countries and climates, and the reſult of many other obſervations.

4. Had all the Weatherglaſſes in the world been made according to one determined ſcale, theſe inconveniencies and uncertainties would have been prevented; which are now unavoidable, and muſt ſtill continue ſo, untill every body agree to graduate their

their Thermometers in the ſame way, or at leaſt determine ſome fixed or unalterable points of heat, to which all the different ſcales of thoſe inſtruments may be reduced.

5. The great and truly honourable Mr. *Boyle*[a] found himſelf very much at a loſs for a ſtandard, whereby to meaſure heat and cold: the common inſtruments ſhewing him no more than the relative coldneſs or heat of things, but leaving him in the dark as to their poſitive degrees. Whence he could not communicate the idea of any ſuch degree to another perſon. Thermometers were then ſuch indefinite and variable things, that it ſeemed morally impoſſible from them to ſettle ſuch a meaſure of heat and cold, as we have of time, diſtance, weight, *&c.* there having been then no method thought upon to compare together any two different Thermometers; or the obſervations made by them. Now as bodies are variouſly affected by various heats, regularly undergoing ſuch and ſuch changes at ſuch and ſuch degrees of it, ſo the faireſt way to fix a ſtandard method of adjuſting Thermometers would ſeem to be from ſome remarkable change a body

[a] Exp. on Cold. Abr. I, p. 579.

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underwent by the application of a certain degree of heat to it. In conſequence of which Mr. *Boyle* propoſed the freezing of the eſſential oil of Aniſeeds as a term of heat and cold that might be of uſe in making and judging of Thermometers; and ſo to graduate them from this point according to the proportional dilatations or contractions of the included ſpirits. He mentioned too the coldneſs requiſite to begin the congelation of diſtilled water as another fixed term that might be propoſed: for he was perſuaded that among the ordinary waters ſome were apt to freeze more eaſily than others. But the objections which he apprehended might be made to this method ſcared him ſo much, that he proſecuted no farther this conſideration of fixing a ſtandard for making and graduating Thermometers all in the ſame way. Which 'tis pity one of his genius and induſtry, and aſſiſted with ſuch opportunities, did not carry farther; as it is of ſuch importance on a thouſand occaſions in the hiſtory and philoſophy of Nature.

6. The ingenious and acute Dr. *Halley*[a] was likewiſe very ſenſible of the bad effects

[a] Phil. Tranſ. Abr. II, p. 36.

of that indefinite way of conſtructing Thermometers; and wiſhed to have them adjuſted to ſome determined points. He, with Mr. *Boyle*, lays aſide the freezing of liquors, as being, in his opinion, points of heat not ſo juſtly determinable but with a conſiderable latitude. And what he ſhews the greateſt fondneſs for is the degree of *temperature*; ſuch as in places deep under ground, where the heat in the ſummer, or cold in winter have been found to have no manner of influence. Thus in a cave cut ſtrait into the bottom of a clift fronting the Sea to the depth of 130 feet with 80 feet of earth above it, Mr. *Boyle*[a] found the ſpirit in the Thermometer to be raiſed to the ſame height both in ſummer and winter. And Meſſrs. *Mariotte*, *De la Hire* and *Maraldi* aſſure us, that in the cave under the royal obſervatory at *Paris* the heat continues always the ſame, ſcarcely altered by the moſt ſultry ſummer heats, or bittereſt colds of that country.

But with Dr. *Halley*'s leave, this degree of *temperature* I do not think a very convenient term for an univerſal conſtruction of Thermometers. Every body cannot go to

[a] Mem. Hiſt. of the Air. Abr. III, p. 54.

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Mr. *Boyle*'s grotto: and it is but few who can have an opportunity of making observations, and adjusting Thermometers in the cave of the *Parisian* observatory. And we are not sure that other deep pits would coincide precisely with the temperature of these places. The difference of soils and different depths might occasion a considerable variation.

7. Another term of heat Dr. *Halley*[a] thought might be of use in a general graduation of Thermometers is that of *boiling spirit of wine.* "Only it must be observed "that the spirit of wine used to this purpose "be highly rectified; for otherwise the "differing goodness of the spirit will occa- "sion it to boil sooner or later, and thereby "pervert the designed exactness." He objects too its great aptness to evaporate, and that in length of time it becomes, as it were, effete, and loses gradually a part of its expansive power. But truly this last mentioned difficulty, though repeated after Dr. *Halley* by several others, and commonly pretty much insisted on, would seem to be of no

[a] Phil. Trans. Abr. II, p. 35.

great

great weight. Well rectified ſpirit of wine, if ſealed up in a glaſs, is pretty unalterable. It cannot evaporate: and by many years experience its force of expanſion has continued the ſame; as, beſide other obſervations, we know eſpecially from the annual regiſters of Mr. *De la Hire*'s ſpirit Thermometer that has been kept in the obſervatory above theſe threeſcore years by paſt.

8. But a much more convenient term of heat, though leſs inſiſted on by Dr. *Halley*, is that of *boiling water*. This he found[a] to be a very fixed and ſettled degree of heat; and which, when once water has acquired it, cannot be increaſed by any longer continuance or length of time. And this point of heat Sir *Iſaac Newton* and Mr. *Amontons* were juſtly very fond of in ſettling the limits of their reſpective Thermometers: wherein too they have been imitated by all thoſe that came after them.

9. Though I could ſcarcely find any ſenſible difference in various waters, differing

[a] Phil. Tranſ. Abr. II, p. 34. See too Amontons in Mem. Acad. Sc. 1699. p. 156. 1702. p. 210.

conſiderably

ESSAY III. considerably in weight, saltness, cleanness, &c. so as that Mr. *Taglini*'s objections [a] against the fixedness of this point are of no force; yet truly this heat of *boiling water* is not at all times and places so absolutely fixed and invariable, as most people are ready to conclude from Dr. *Halley*'s and Mr. *Amontons*'s observations. The fixedness or volatility of water depends very much not only on the cohesion of its particles, but also on the pressure of the incumbent atmosphere. [b] For in a vessel much exhausted of air, water and other liquors, being freed of most of the ordinary pressure they undergo, boil in a very moderate degree of warmth, much below what in the open air is usually requisite to set them a boiling. And agreeable hereto *Fahrenheit* actually found [c] that water was capable of a greater or less degree of heat in boiling, according to the greater or less weight of the atmosphere, or the greater or less height of the Mercury in the Barometer. But in ordinary changes of the weather the

[a] See Mem. Acad. Sc. 1730. p. 714.

[b] See Boyle Physico. Mech. Exp. Abr. II, p. 473. 474. Newton. Opt. p. 318.

[c] Phil. Trans. Abr. VI, 2. p. 18. Boerh. Chem. I, p. 171.

difference

difference is not very great[a]. And farther we may avoid all errors that might arise from any thing of that sort, if we make our observations on the heat of boiling water, and adjust this term of heat at a middle state of the atmosphere in places near the level of the sea, when the Mercury in the barometer stands at about 30 inches or a very little under it. And the same caution will be necessary in judging of the heat of *boiling spirit of wine*, or of the *boiling heat* of any other liquor.

10. It was on this principle chiefly of the determined fixedness of the heat of *boiling water* that Mr. *Amontons*[b] contrived his universal Thermometer. It was indeed a pretty contrivance: but it never was, nor never could be of universal use; nor could

[a] It is not so great as Dr. *Boerhaave* (Chem. I, p. 171.) in giving an account of *Fahrenheit*'s observations reckoned. In an alteration of 3 inches in the height of the Mercury in the barometer he says the boiling heat is found to differ 8 or 9 degrees. I did not find it to vary so much by the different weights of the atmosphere. From the experiments I have made I judge that by the rise or fall of the quicksilver an inch in the barometer the boiling heat of water varieth somewhat less than 2 degrees.

[b] Mem. Acad. Sc. 1702. p. 204. &c.

it

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it anſwer the deſign of its ingenious author. Its conſtruction is too difficult and complex; the machine itſelf is too bulky and incumbered to be eaſily managed, or carried from place to place. And then it is ſuppoſed to be fitted at a due temperature of the air, as in the ſpring and autumn at *Paris*: which, beſide that it is in itſelf ſomething too indefinite, at other times and places we cannot well be ſure of. And the air of that temperature he reckoned to be dilated juſt one third by the heat of boiling water. But the dilatation of the air is not ſo regularly proportional to its heat; nor is its dilatation by a given heat near ſo uniform as he all along ſuppoſed. This depends much on its moiſture: [a] for dry air does not expand near ſo much by a given heat, as air ſtored with watery particles; which by being turned into ſteam increaſe vaſtly the ſeeming volume of the air. So then as Mr. *Amontons*'s Thermometer is affected by all theſe and other inconveniencies [b], it is no wonder it was

[a] See Hiſt. Acad. Sc. 1708. p. 15. Mem. p. 370. Muſſchenbr. Tent. Exp. Acad. Cim. Add. p. 40. Eſſ. de Phyſ. §. 1402.

[b] See Mr. de Reaumur in Mem. Acad. Sc. 1730. p. 654.

imitated

imitated by very few, and never came to be of general uſe in the world.

11. From this one determined point of the heat of *boiling water* there may however be laid down a general method of conſtructing Thermometers all in the ſame way, ſo as that they ſhall correſpond with one another in all the various degrees of heat. It is, as Mr. *Boyle*[a] propoſed long ago, by marking the degree of expanſion or contraction of the fluid of the Thermometers, as the heat applied is either greater or leſs than that of *boiling water*. Suppoſing for example the whole volume of this fluid to conſiſt of 10000 parts it is to mark on the tube where that volume is expanded by heat, or contracted by cold 1, 2, 3, 4, *&c.* of theſe parts. All which may be done at any time by different perſons and in different places, ſo as that they ſhall anſwer preciſely to one another.

12. This is a very plauſible method, and has been actually tried by ſome, as we ſhall afterwards have occaſion to ſee. And yet in practice it will not be found very eaſy to

[a] Exp. on Cold. Abr. I, p. 579.

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determine exactly all the divisions from the alteration of the bulk of the fluid; beside other unavoidable inconveniencies and uncertainties we shall by and by have occasion to take notice of. It is sufficient and will be much easier and more convenient, in settling an universal method of constructing Thermometers, to determine at least two fixed points of heat at a considerable distance the one from the other; and to divide on the tube or scale the intermediate space into any convenient number of equal parts or degrees. *Boiling water*, in the circumstances we proposed, we just now found to be a pretty uniform and fixed degree of heat. And *water* just *freezing*, if that come out always the same, will answer the purpose most readily of any degree we could think of.

13. It is true Dr. *Halley* [a] thought this to be a point admitting a considerable latitude. And some have suspected that water freezes at different degrees of heat in different seasons, countries and climates. And Dr. *Cyrilli*'s observations [b] would seem to confirm

[a] Phil. Transf. Abr. II, p. 36.
[b] Phil. Transf. N. 424. p. 336. N. 430. p. 189. N. 434. p. 407. 408. N. 435. p. 464.

it,

it. At *Naples* he found water to freeze when his Thermometer was 10 degrees above the freezing point as it had been conſtructed in *England* by the directions of the Royal Society. And Father *Martini* [a] talks of the froſts in the province of *Pekin* in *China* as greater than its latitude of 42 degrees would induce one to expect, the rivers being often frozen for four months together, *&c.* And adds, that it is ſurpriſing the *Europeans* ſhould remain unaffected by this cold; and ſlight it as unable to produce ice in their quarter of the world. From all which one might be ready to conclude with Dr. *Derham* [b], Profeſſor *Muſſchenbroek* [c] and others, that the farther north we go, it takes the greater degree of cold to freeze water. And what might ſtrengthen ſuch a ſuſpicion is, that I found ſome of the *Dutch* mercurial Thermometers made at *Amſterdam* in which the *freezing point* was marked at *gr.* 32, to be a degree or two lower here when immerſed in thawing ſnow or beaten ice beginning to melt.

[a] Atlas Sinenſ. p. 27. See too Boyle Exp. on Cold. Abr. I, p. 577. Reaumur in Mem. Ac. Sc. 1734. p. 233. [b] Phil. Tranſ. Ibid.
[c] Eſſ. de Phyſ. §. 913.

14. But

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14. But I am convinced all this ſeeming difference flows from the careleſſneſs of obſervers, or errors of the workmen. Or what if Dr. *Cyrilli* kept his weatherglaſs ſhut up and ſheltered in a houſe while it freezed abroad? As I know is but too ordinary with thoſe who pretend to keep regiſters of the Weather. To ſatisfy myſelf in this article I took a very fair method of enquiring if there was really any ſuch difference in the cold of *freezing water* in different climates. I marked two mercurial Thermometers here in the latitude of 56 deg. 20 min. and got a correſpondent of mine to mark ſome others at *London* in the latitude of 51 deg. 32 min. all at the freezing point in ſnow or powdered ice melting. And upon exchanging theſe Thermometers we found them, when again immerged in thawing ſnow or ice, ſtill to point at the very ſame marks preciſely without the leaſt obſervable difference. Were there any odds occaſioned by the difference of climates would not near 5 degrees of latitude have ſhewn it very ſenſibly [a]? And at this

[a] The univerſality and fixedneſs of the term of congelation I can now affirm with ſtill greater confidence and

this ſame very mark does the quickſilver ſtand in ſuch thawing ice or ſnow at all ſeaſons of the year, in ſummer or winter, in cold weather or warm weather, under a light or a heavy atmoſphere, *&c.* From whence I conclude the *freezing point* to be a very conſtant and ſettled degree of heat, more fixed and determined than even that of *boiling water*, and conſequently very fit to be one of the fixed limits in adjuſting our Thermometers.

15. The fixedneſs then of the *freezing point* I think we may take for granted, and ſufficiently eſtabliſhed by theſe obſervations, notwithſtanding what Profeſſor *Taglini* may have ſaid to the contrary; and the unneceſſary conceſſions Mr. *De Reaumur* thought fit to make on that head [a]: and the obſervations adduced by Dr. *Muſſchenbroek* [b], by which he would prove the *freezing of water*

and certainty after the trials I lately made, not only at London, but at Paris in the latitude 48 deg. 50 min. and Dijon in the latitude 47 deg. 20 min. by which I found that preciſely the ſame degree of cold was requiſite to freeze water in Burgundy and in the Iſle of France, as in our northern climates.

[a] Mem. Acad. Sc. 1730. p. 712.

[b] Tent. Acad. Cim. Add. p. 184. 185. Eſſ. de Phyſ. §. 913. &c.

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to begin in various degrees of cold, depending on ſome ſaline additional mixture from the air. All which may be allowed to ſhew that in ſome places and circumſtances water freezes more or leſs eaſily, though the degree of cold in this act of *natural freezing* be, for any thing we can perceive, in all pretty nearly the ſame.

16. The cold of *Water beginning to freeze*, or, which is the ſame thing, of *Ice beginning to melt*, is ſuch a convenient fixed point, ſuch a remarkable period of heat and cold, and withall ſo eaſily determined by immerging the bulb of the Thermometer in thawing Snow or Ice, that it is ſurpriſing ſo few have taken it into the ſcale of their Thermometers, that theirs might be the better compared with other people's obſervations. We are not abſolutely ſure even of this part of the ſcale of the *Florentin* weatherglaſſes. And the French have not yet preciſely determined the *freezing point* in Mr. *De la Hire*'s ſtandard Thermometer of the Obſervatory, by which the regiſter of the weather has been ſo very long kept; and with which they ſometimes compare other obſervations: And moſt of the

other obſervations of the Weather both in the Memoirs of the Academy of Sciences, and in the Tranſactions of the Royal Society are done with Thermometers ſo negligently conſtructed, that we are left altogether uncertain of their degrees of heat: moſt of thoſe that have the *freezing point* marked on them having it very erroneouſly graduated, and alſo having no other determined or known period of heat; and ſo coming to be as indefinite and uncertain as the others.

17. The great Sir *Iſaac Newton* thought the ſettling the degrees of Heat and Cold well worth his notice; and, as he carried every thing he meddled with beyond what any body had done before him, and generally with a greater than ordinary exactneſs and preciſion, ſo he [a] laid down a method of adjuſting Thermometers in a more definite way than had been done hitherto. We have already [b] found it neceſſary, at leaſt convenient, to fix on two determined periods of heat to make up an intelligible ſcale of its various degrees. We have likewiſe [c] found *Water freezing* and *Water boiling* to be in two

[a] Phil. Tranſ. Abr. IV, 2. p. 1. &c.
[b] §. 12. [c] §. 8. 14.

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points of heat very convenient for ſuch a purpoſe. And theſe are the very degrees of heat he pitched upon. The liquor he uſed was Linſeed Oil, a homogeneous fluid enough, and capable of a conſiderable rarefaction, and not having been obſerved to freeze even in very great colds, and able to bear a great heat without boiling. Suppoſing the bulb when immerged in *thawing ſnow* to contain 10000 parts, he found the oil expanded by the heat of the *human body* ſo as to take up $\frac{1}{39}$ more ſpace, or 10256 ſuch parts; and by the heat of *Water boiling* ſtrongly 10725; and by the heat of *melting Tin* 11516, beyond which he did not carry his Oil Thermometer. So that, reckoning the *freezing point* as a common limit between heat and cold, he began his ſcale there, marking it *gr.* 0; and the heat of the *human body* he made *gr.* 12; and conſequently the heat of *boiling Water* was expreſſed by *gr.* $34 = \frac{725 \times 12}{256}$; and *melting Tin* by *gr.* 71.

18. I wiſh the world would have received this or any other determined ſcale for adjuſting their Thermometers. But I ſuppoſe they might be apprehenſive of ſome incon-

inconveniences in this ſcheme. Beſide ſome inconſiderable arithmetical errors in Sir *Iſaac*'s paper, and ſome few not accurately enough made obſervations of no great moment, they would allege [a] that he had expreſſed himſelf as if he had thought the point of *freezing Water* to be the loweſt degree of heat. And indeed he has not mentioned any winter cold beyond that; though, as we ſhall take notice on another occaſion, we ſometimes experience vaſtly intenſer colds: in conſequence of which it would be eaſy to protract Sir *Iſaac*'s ſcale downward below *gr.* 0, or the freezing point, and ſo to make it as ſerviceable in common uſe, even for great degrees of cold, as other Thermometers.

But there is another difficulty which will hold in all oil Thermometers, or any made with a viſcid liquor, that it adheres too much to the ſides of the tube. In a ſudden cold or fall of the oil a good deal ſticks by the way, and only ſinks gradually after, ſo that at firſt the ſurface appears really lower than the preſent temperature requires. And beſide, as at all times ſome muſt continue to ſtick and moiſten the inſide of the tube, in different degrees of heat and cold the oil,

[a] See Amontons in Mem. Acad. Sc. 1703. p. 233.

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becoming alternately more or leſs viſcid, will adhere ſometimes more and ſometimes leſs; and therefore will inevitably diſturb the regularity and uniformity of the Thermometer.

19. The *Florentin* Thermometers made with ſpirit of wine were by no means ſo liable to errors of this kind. The Spirit indeed muſt moiſten the inſide of the tube; but as this is ſo very thin a liquor, it is probable that moiſtening is always pretty uniform, and extremely thin; ſo as that it can have no other effect but to render the tube a very little narrower. And ſo truly rectified ſpirit of wine has been more uſed in Thermometers than any other liquor. It is very tickliſh, is eaſily and very much affected by heat and cold; nor does it ſoon gather air bubbles, as watery fluids are ready to do even in no very great heats. But, as we ſaid before [a], thoſe ſpirit Thermometers did not uſe to be reduced to a fixed ſtandard. At length Mr. *de Reaumur* [b] has in a very ingenious way attempted to eſtabliſh a general conſtruction of ſuch Thermometers, which

[a] §. 3. 4. 16.
[b] Mem. Acad. Sc. 1730. p. 645, &c.

might

might be copied at all times, and in all countries; and so to settle, as it were, a general correspondence of observations that should be made by such instruments. He adjusted his Thermometer to the *freezing point* by an artificial mixture; and then, immerging it in *boiling Water*, found how much it was dilated by that heat, in the way Sir *Isaac Newton* had managed his oil Thermometers. The quantity of spirits in his glass he supposed to be 1000 parts; and he found to the bulk of how many of these parts the liquor was dilated by that boiling heat. The stronger the spirits, this dilatation is found always the greater. The best spirit of wine commonly sold from this *artificial freezing of Water* to that *boiling heat* was dilated $87\frac{1}{2}$ of those parts [a]: and a mixture of such a strong spirit and water in equal portions (which would be about the state of common Brandy) was expanded only $62\frac{1}{2}$ such parts [b]. He speaks too of a spirit so strong as to have the dilatation of 90 in its *boiling heat* [c]. But what he judged most convenient for his ordinary Thermometers was a spirit of such a degree of strength as in the above period of

[a] Ibid. p. 690. [b] Ibid. p. 692.
[c] Ibid. 1734. p. 261.

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heat to be dilated juſt 80 of theſe 1000 parts [a].

20. This imitation of Sir *Iſaac Newton* with ſpirit of wine inſtead of oil is a promiſing enough method of making a ſettled ſtandard ſcale for Thermometers: and accordingly one of them conſtructed by Mr. *de Reaumur* himſelf is now placed in the royal obſervatory at *Paris*; and a journal kept of the weather by it. And others conſtructed in the ſame way have been ſent to different quarters of the world to compare the degrees of heat of different climates: a project long ago of the great *Colbert*'s [b], but never till now ſatisfactorily executed. Obſervations have been made with them in the Torrid Zone. And the *French* Academicians had them in their philoſophical embaſſy to the north for determining the figure of the Earth. And yet I am afraid theſe Thermometers are conſtructed on principles, that will by no means be found ſo accurate as were to be wiſhed and expected in ſuch a caſe. Mr. *de Reaumur* [c] determines his

[a] Ibid. 1730. p. 697. 698. and fig. 8.
[b] See Mem. Acad. Sc. 1702. p. 209.
[c] Ibid. 1730. p. 655. 656. 680. 681. 712.

freezing

freezing point, not from *thawing ſnow* or *ice*, but from an *artificial congelation of water* in warm weather. And as he [a] uſes very large bulbs for his glaſſes, it may be 3 or 4 inches in diameter, I am apt to think that, before the due temperature of the ſurrounding ice can be thoroughly propagated to the whole contained ſpirits, it will be quite melted down again; and ſo the *freezing point* marked much higher than what it ſhould be [b]. He indeed [c] ſpeaks of a quarter of an hour as ſufficient to bring the contained ſpirit to the temperature of the ambient *medium*. But as far as I can judge from my obſervations (and many have I made on this ſubject) it would rather take ſome hours to penetrate thoroughly ſuch a great bulk of any liquor, and reduce it fully to its own degree of heat. And ſo Thermometers of great bulbs can never be uſed with ſucceſs, or truſted to in common experiments of the heat of bodies, or obſervations of the weather: as we may be ſatisfied by

[a] Ibid. p. 660. 710.

[b] From collating ſome obſervations together I reckon Mr. *De Reaumur*'s mark of freezing water, inſtead of coinciding with *Fahrenheit*'s *gr.* 32, as it ſhould do, to correſpond with *gr.* 34 or a little above it.

[c] Ibid. p. 711.

collating

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collating the ſeveral obſervations in the royal obſervatory made with *De la Hire*'s and *De Reaumur*'s Thermometers, which at different times I find to quadrate very ill together, juſt I ſuppoſe from that cauſe of the different ſizes of their bulbs [a]. For large bulbs can never be ſo quickly influenced by great and ſudden variations of heat and cold, as to make theſe changes, if they laſt but a ſhort while, ſufficiently remarkable, or to ſhew their real and full quantities. Small bulbs and ſmall tubes are (notwithſtanding the imaginary faults and difficulties ſtarted againſt them by Mr. *De Reaumur* [b]) vaſtly more convenient, and may be conſtructed ſufficiently accurate. I have them made with capillary bores that correſpond almoſt preciſely to one another in all degrees of heat; and conſequently muſt be allowed to have all the exactneſs that can be imagined or deſired in ſuch inſtruments.

21. But if we cannot truſt to Mr. *De Reaumur*'s *point of congelation*, what ſhall we ſay to his other fixed term, to wit the

[a] The diameter of the bulb of Mr. *De Reaumur*'s I found to be about $3\frac{2}{3}$ inches; while the other was leſs than 2 inches. [b] Mem. Acad. Sc. 1730. p. 650. 656. 659.

heat

heat of *boiling water?* This, I humbly think, is, under his management, ſtill more vague and uncertain. As water, were it ſurrounded by melted tin, though it would boil and foam and ſuffer very great agitation, is yet incapable of being warmed beyond its ordinary great boiling heat, and continues always much colder than melted tin; juſt ſo, as I experienced upon trial, ſpirit of wine, though immerged in boiling water, can never acquire near ſuch a great heat, but keeps always a good deal under it, though bubbling and foaming and toſſed to a very great degree. The ſpirit then in the Thermometer is abſolutely incapable of ſuch a great heat as Mr. *De Reaumur* aſcribed to it; and that not by a ſmall or trifling difference. I find highly rectified ſpirit of wine cannot be heated beyond *gr.* 175 or ſo in *Fahrenheit*'s Thermometer, while boiling water raiſeth the quickſilver 37 degrees higher: and common brandy was able to conceive a heat no greater than about *gr.* 190. So far was Mr. *De Reaumur* in the wrong when he thought that all ſpirits, weak and ſtrong, immerged in *boiling water* received a given degree of heat, and that equal to the heat of the ſurrounding water. I ſuppoſe his ſtandard

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ſtandard ſpirit could take on a heat of about *gr.* 180; leſs by 32 degrees than what he reckoned.

22. Beſide all this I truly think ſpirit of wine, though good enough for ordinary weatherglaſſes in temperate climates, is yet not ſo fit a fluid whereof to make ſtandard Thermometers. It is incapable of bearing very great heats, or very great colds. It boils ſooner than any other liquor. And though it keeps fluid in pretty ſtrong colds, yet it would ſeem from ſome experiments that it does not condenſe very regularly in them. And at *Torneao* near the polar circle the winter cold was ſo violent, that the ſpirits were frozen in all their Thermometers [a]. So that the latitude of heat ſpirit of wine is capable of expreſſing is by much too limited to be of very great or univerſal uſe.

23. What fluid then ſhall we take for our Thermometers? We have found inconveniences in Air, Oil and Spirits; and Water is more exceptionable than any of them. We have, it ſeems, nothing left but Quickſilver. This is a very moveable and tickliſh

[a] See De Maupert. Fig. de la Terre. p. 58.

fluid; it both heats and cools faſter than any liquor we know, or have had occaſion to try, faſter I am ſure than water, oil or even ſpirit of wine; it never freezes by any degree of cold hitherto obſerved; and bears a great deal of heat before it arrives at a boiling expanſion; and, if well purified, does not wet or ſtick to the inſide of the tube. Dr. *Halley* [a], though appriſed but of ſome of theſe remarkable properties, thought it a fluid very fit for Thermometers, were but its expanſion more conſiderable. However as any inconvenience ariſing from this conſideration may be avoided by making the bulb have a great proportion to the tube, ſo it is now very deſervedly come to be in the greateſt uſe in the Thermometers that people would moſt truſt to. It is ſaid [b] that they were firſt contrived by that curious Mathematician *Olaus Roemer*. Mr. *Fahrenheit* in *Amſterdam*, and other workmen in that country manufactured very many of them, and that in a portable and mighty convenient form for many purpoſes, making them very ſmall, and incloſing the tube in another glaſs hermetically ſealed. From *Hol-*

[a] Phil. Tranſ. Abr. II. p. 34.
[b] See Boerh. Chem. I. p. 720.

land

ESSAY III.

land they were diſtributed into different quarters of the world, and have been imitated in ſome other places. And now they are made no where in greater perfection or with greater exactneſs than by our countryman *Wilſon* at *London*.

24. As *Roemer*'s or *Fahrenheit*'s ſcale is convenient enough, I wiſh it were univerſally kept and uſed, to preſerve an uniformity in our obſervations; and ſo that every body, when they ſpeak of experiments wherein the heat of bodies was adjuſted, or pretended to be obſerved by Thermometers, were to have the ſame language; and ſo be univerſally underſtood.

In this Thermometer the bulb is ſuppoſed to contain, as Dr. *Boerhaave* [a] and Dr. *Muſſchenbroek* [b] tell us, 11124 parts of quickſilver, which ſtands at the loweſt mark or *gr.* 0. in a very intenſe intolerable cold, being ſurrounded with a mixture of ſnow or beaten ice and *ſal* ammoniac or ſea ſalt [c].

If the ſame bulb be immerged in *ſnow* or *ice thawing* naturally, or in *water be-*

[a] Chem. I. p. 174. [b] Eſſ. de Phyſ. §. 948.
[c] Fahrenh. in Phil. Tranſ. Abr. VI, 2. p. 52. Muſſchenbr. Diſſ. Phyſ. p. 680. Eſſ. de Phyſ. §. 948.

ginning

ginning to freeze, the quickſilver is dilated, and ſo riſes in the tube 32 of theſe 11124 parts; and therefore the ſpace of the tube from *gr.* 0. to the *freezing point gr.* 32 is divided into theſe 32 equal parts [a].

When the Thermometer is placed in water brought to ſtrong *boiling* (the atmoſphere being in the condition formerly mentioned [b]) the quickſilver is dilated 212 of theſe parts beyond its original bulk of 11124, ſo as now to poſſeſs in the bulb and tube together a ſpace equal to 11336 ſuch parts: and the ſpace from *gr.* 32 to *gr.* 212 is divided into 180 equal parts or degrees of the Thermometer [c]; which, if the tube be long enough, may be protracted as far as is convenient. It may go well enough to *gr.* 600, and not much farther; for with a heat but little greater than that the Mercury begins to boil.

25. Dr. *Boerhaave* is not always quite conſiſtent with himſelf in his accounts of the number of parts into which the mercury in the bulb is ſuppoſed to be divided.

[a] Fahrenh. in Phil. Tranſ. Abr. VI, 2. p. 52.
[b] §. 9.
[c] Fahrenh. in Phil. Tranſ. Abr. VI, 2. p. 18. 52.

In

ESSAY III. In another place [a], inſtead of 11124 he reckons only 10782; and afterwards [b] he raiſes it to 11520 (which I take to be nearer the truth) and yet ſtill ſpeaks of a given heat as expanding the quickſilver the ſame number of parts as in the other ſupputation. Which of his ſuppoſitions is right I am not abſolutely ſure of before making trial, nor need we much to care. For without all that *apparatus* I humbly think the eaſieſt and ſureſt way too, and what in practice I have followed, is not to be ſollicitous about the bulk of the quickſilver; but to fill the bulb and tube ſo, as that in freezing water or melting ice the mercury ſhall ſtand at a convenient height, which muſt be very nicely marked *gr.* 32; and then as accurately to obſerve where it ſtands when dilated by the heat of boiling water to *gr.* 212. The intermediate ſpace is then divided into 180 degrees: which ſcale may be protracted upwards and downwards as far as we ſhall judge convenient. In the conſtruction of theſe Thermometers the two great limiting or fixed points being *freezing water* and *boiling water*; which we found to be the

[a] Chem. I. p. 165. [b] Ibid. Expl. Tab. V. fig. 3.

moſt

moſt convenient periods of heat for adjuſting theſe inſtruments. ESSAY III.

26. Indeed in all this we have ſuppoſed the bore of the tube to be perfectly cylindrical; which cannot always be obtained. But though it be tapering or ſomewhat unequal, it is eaſy to manage that matter by making a ſmall portion of the quickſilver, as much for example as fills up a half or, if you pleaſe, a whole inch, ſlide backward and forward in the tube; and by this means to find the proportions of all its inequalities, and from thence to adjuſt your diviſions to a ſcale of the moſt perfect equality.

27. The conceiving the bulk of the contained mercury at the beginning of the ſcale to be either 10782, or 11124, or 11520, or, as I gueſs it ſhould be, near 11790 parts, and its expanſion from thence by the heat of boiling water to be 212 of theſe parts, was to be ſure a diviſion originally quite arbitrary. And I confeſs there might have been a more convenient one fixed upon at firſt, and adopted yet, if this were not now ſo univerſally known and uſed; and Thermometers conſtructed in that form every

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where ſcattered up and down, and in the hands of moſt of the Virtuoſi in *Europe*. I ſhall readily allow that Mr. *de l'Iſle*'s at *Peterſburg* might have had a greater look of ſimplicity. [a] In his the whole bulk of quickſilver, when immerged in *boiling water*, is conceived to be divided into 10000, or rather 100000 parts: and from this one fixed point the various degrees of heat either above or below it are marked in theſe parts on the tube or ſcale, by the various expanſion or contraction of the quickſilver in all the imaginable variety of heat. "As pure "mercury," ſays he, "is of the ſame na- "ture every where, nor is liable to any al- "teration from being incloſed in a tube; "and as it is probable that, taking it equal- "ly purified, it will in different countries "be ſubject to the ſame expanſion, if ex- "poſed to the ſame degree of heat; for "this reaſon he is perſuaded theſe Ther- "mometers may very well ſerve to com- "pare the temperature of different coun- "tries." And indeed ſuch a conſtruction bids fair for being a very good ſtandard method for graduating Thermometers all in the ſame way; and is much leſs liable to un-

[a] Phil. Tranſ. N. 441. p. 222.

certainties than that ſimilar one of Mr. *De Reaumur*, whereof we have already given an account [a]. However if Mr. *De l'Iſle* had pleaſed I cannot but think it would have been rather ſomething better to have made the integer of 100000 parts, or fixed point at *freezing water*; and from thence to compute the dilatations or condenſations of the quickſilver in thoſe parts. All the common obſervations of the Weather, *&c.* would have been expreſſed by numbers increaſing as the heat increaſed; which ſurely is the more natural way. Nor would there have been great incongruity or inconvenience in expreſſing, after the manner of Mr. *De Reaumur*, the few obſervations we have below ſimple freezing by numbers of contraction below *gr.* 0, or 100000.

28. But, as I ſaid before [b], however promiſing in theory ſuch a ſcheme may appear, it will not in practice be found very eaſy to determine exactly all the diviſions from the alteration of the bulk of the contained fluid. And beſide, as glaſs itſelf is dilated by heat, though in a leſs proportion than quickſilver, ſo that it is only the exceſs

[a] §. 19. 20. 21. [b] §. 12.

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of the dilatation of the contained fluid above that of the glaſs that is obſervable; if different kinds of glaſs be differently affected by a given degree of heat, this will make a ſeeming difference in the dilatations of the quickſilver in the Thermometers conſtructed in the *Newtonian* method, either by Mr. *De Reaumur*'s, or Mr. *De l'Iſle*'s rules. Now Dr. *Boerhaave*[a] from *Fahrenheit*'s obſervations ſpeaks of different kinds of glaſs as very differently affected by heat. And upon enquiry I was informed that Dr. *Muſſchenbroek* found by his Pyrometer, that tubes of different ſorts of glaſs were variouſly affected, ſome more, ſome leſs, by the ſame degree of heat. From whence Thermometers conſtructed of ſuch different ſorts of glaſs would neceſſarily make the ſeeming dilatation of the contained fluid appear at different degrees in the very ſame point of heat. And accordingly Mr. *Campbell*, an ingenious and worthy member of the Royal Society, has, by experiments made with all imaginable exactneſs and ſcrupuloſity, found in Thermometers conſtructed in Mr. *De l'Iſle*'s way the quickſilver to ſtand at different degrees of the ſcale when immerged in thawing

[a] Chem. I. p. 141.

ſnow.

ſnow. In ſome it was at *gr.* 154, in others at 156, and in another at 158: and emptying the tubes, and preparing them again, and that ſometimes with other mercury, he always, even in a great many trials, found the reſult come out the very ſame. So careful and exact had he been that the ſame tubes gave always the ſame degrees of dilatation as nearly as could be expected in ſuch nice and ſubtile experiments. One of Mr. *De l'Iſle*'s own Thermometers, which I tried very carefully, gave me always the quickſilver at about *gr.* 150. In another of his, where on the one ſide he has put *Fahrenheit*'s ſcale, I ſee *gr.* 32 over againſt his own *gr.* 148 ½. In one conſtructed by Mr. *De Monier* at *Paris* on *De l'Iſle*'s principles I ſaw the *terme de congelation* put down at *gr.* 148. Nay by Mr. *De l'Iſle*'s own accounts I find his Weatherglaſſes diſagreeing conſiderably from one another. So uncertain and precarious would this way of conſtructing Thermometers ſeem to be. From all which I humbly think, that it is better and more convenient to drop this method altogether, and to fix on two points of heat at a conſiderable diſtance the one from the other; and to divide the intermediate ſpace of the tube

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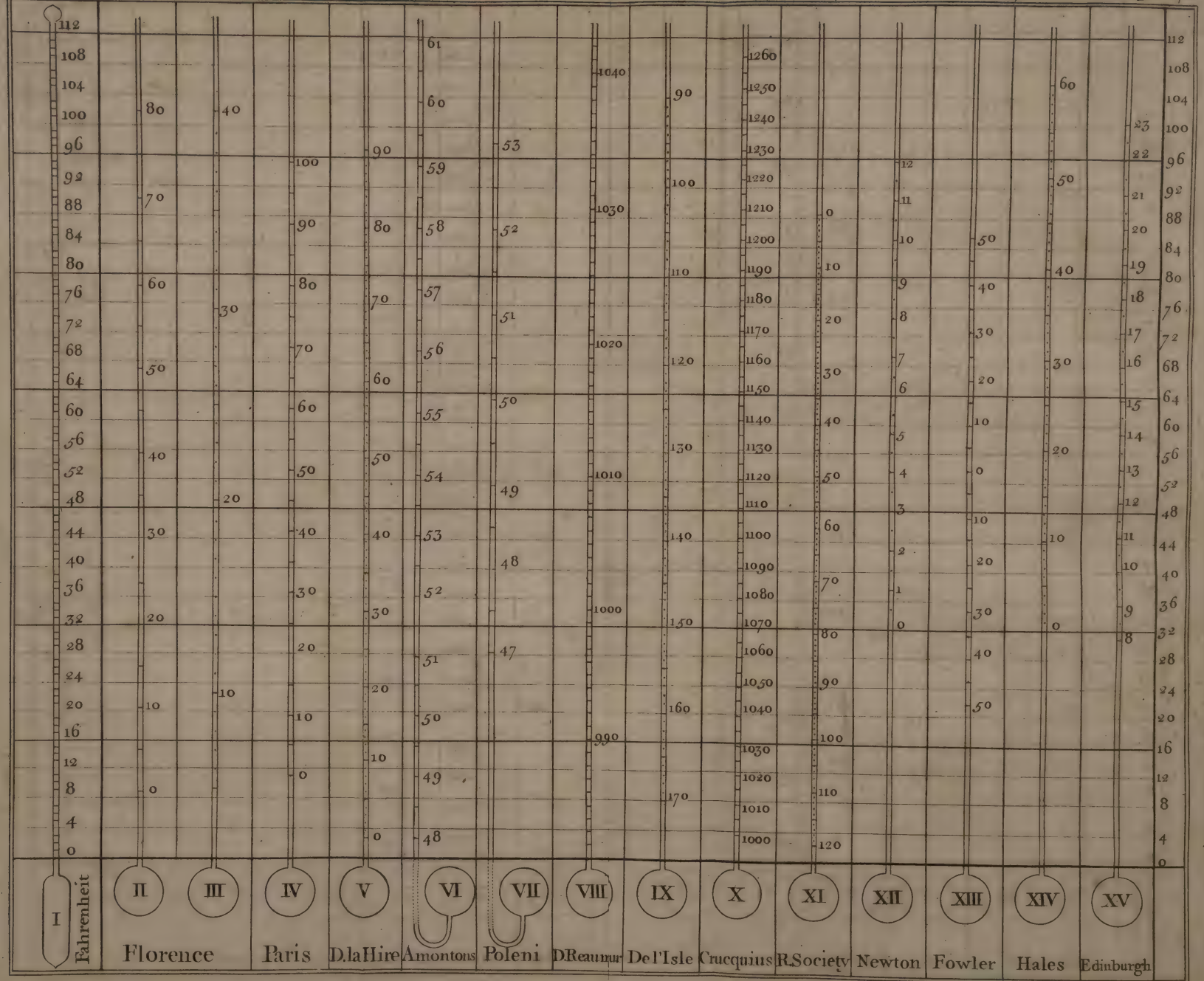
into a convenient number of equal parts or degrees: as we juſt now propoſed[a] to be done in our imitations of *Roemer*'s or *Fahrenheit*'s Thermometers.

29. To enlarge our views of heat, and to enable us to compare other Thermometers with theſe (which after this I wiſh were always to be the ſtandard) it would not be amiſs to obſerve a great many remarkable periods of heat and cold that have been taken notice of by others, and to determine where they fall on *Fahrenheit*'s ſcale. We ſhould determine about what degrees on it the ſeveral ſorts of weather are marked; the various degrees of animal heat; what degrees of heat reduce ſuch and ſuch conſiſtent bodies into a fluid ſtate; the quantities of heat required to boil the fluids we have occaſion to try, *&c.* But the comparing the different Thermometers which have been in uſe in the world; and the determination of the various degrees of heat in bodies make fruitful enough ſubjects for other curious and uſeful enquiries.

[a] §. 24. 25. 26.

THE

THE COMPARISON OF Different THERMOMETERS.


I Fahrenheit
II Florence
III
IV Paris
V D.la Hire
VI Amontons
VII Poleni
VIII D.Reaumur
IX De l'Isle
X Crucquius
XI R.Society
XII Newton
XIII Fowler
XIV Hales
XV Edinburgh

London, 1740.

AN ESSAY

Towards comparing Different THERMOMETERS With one another.

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WE had occaſion formerly to take notice of the great uncertainty of thermometrical obſervations by reaſon of the vague and inconſtant way that people had of making their inſtruments. However it will be worth while narrowly to enquire, as far as our lights can carry us, into the principles on which they were conſtructed; and if we can find out theſe principles ſo as to compare the old Thermometers with any regular one we are well acquainted with, we ſhall recover, as it were, the loſt obſervations of our predeceſſors; loſt for want of knowing the meaning of their numbers and graduations. And then obſervations made

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at different times and places by any known instruments will be no longer useless memorandums. We shall be able to compare them with one another, and with our own observations, and with the degrees of heat we are acquainted with.

2. As *Sanctorio* seems to be the first who had a notion of measuring the various degrees of heat by the dilatation of bodies, people will be apt to expect, and many will fondly wish, that he had left us his method of numbering the degrees of his Thermometers. Though to acknowledge the truth it would be a matter of more curiosity than use, as they were affected by the difference of weight of the atmosphere, as well as by the difference of heat of the ambient medium. To remedy which inconvenience the Virtuosi of the Cimentin Academy contrived their Thermometers in a better way; carefully sealing up the included spirits from any influence of the gravity of the Atmosphere; and marking on the tubes, or on the scales fixed to the tubes, numbers whereby to judge of the various dilatations of those spirits by the various degrees of the heat applied.

I am

I am surprised to find Dr. *Musschenbroek*[a], who had been at the pains to give a latin translation of their whole work and to enlarge and embellish it with excellent additions, representing these *Florentine* Thermometers as constructed in a very loose, arbitrary and indefinite way, and without any rule at all. This is an imputation to which they are less liable than many others that came after them. They made them of several sorts, some with greater and some with less accuracy. But in the constructing of those in which they could most confide[b], they tell us expressly at what degree the spirit stood in the ordinary cold of simple ice or snow. Which, as their experiments were done within doors in *Italy*, I take commonly to have been in a thawing state, and consequently to point out to us the degree of freezing water, which we found[c] to be a very fixed period of heat and cold, coinciding, we know[d], with our *gr.* 32. Thus in their 1st sort this point of heat fell at *gr.* 20[e]; and in their 2d to about *gr.* 13 ½[f].

[a] Eff. de Phys. §. 947. [b] Tent. Exp. Acad. Cim. p. 5. [c] Eff. III. §. 14. [d] Ibid. §. 24. [e] Tent. Exp. Acad. Cim. p. 2. 7. [f] Ibid. II. p. 129.

So

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So then we have one fixed and intelligible point of heat in their Thermometers, which is more than we have in those of many others. But from one point we cannot judge of the rest of the numbers: and it must be confessed their highest degree of heat is not defined in a way we could have wished. They tell us that in their first or long Thermometer the spirit, when exposed to the great midsummer heats in their country, rose to where they marked *gr.* 80[a]. And the Spirit in the 2d or smaller Thermometer in such a heat stood at *gr.* 40[b]. This indeed is a very incongruous way of graduating Thermometers; as the great heat of the summer sun is such an indefinite degree of heat in different days, years, climates, *&c.* And yet by good chance there is left us a way to judge of the particular summer heat they happened to pitch upon; and of finding whereabouts it would have fallen in a Thermometer constructed in *Fahrenheit*'s way, which we have taken up as our standard. To affirm this will I know be looked on at first sight as pretending to a thing in itself lost and now impracticable. But *Borelli* and *Malpighi*, two curious and careful observers of nature,

[a] Ibid. p. 2. 4.

[b] Ibid. p. 4.

luckily

luckily had occaſion to tell us that the *viſcera* of ſome hot animals, ſuch as of Cows, Deer, &c. raiſed the ſpirit in the ſmall *Florentine* Thermometer to about *gr.* 40. the very degree of this their ſummer ſun heat. And that animal heat I find to coincide with *gr.* 102. or thereabouts in ours. From which two periods of heat determined in both Thermometers we can make a pretty good eſtimate of all obſervations made by any of the regular and well conſtructed *Florentine* glaſſes; as we may ſee by looking on the Table at N° I. II. III.

3. The Thermometers that came to be uſed in the world were all imitations of thoſe of the *Academia de l'Cimento*, but not conſtructed in ſuch a regular way or upon ſuch determined principles. In *France* Mr. *Hubin* was employed in making them for the *Academie des Sciences* at *Paris*. But we find they were not made all perfectly alike. The *Indian* Miſſionaries [a] tell us that they uſed thoſe that were graduated loweſt. However we may reckon at a medium that which Mr. *Amontons* gives us a view of in

[a] Mem. Acad. Sc. 1666. —— 1698. VII. p. 835.

the

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the Memoirs[a], under the name of the *Ancienne Thermometre.* In it the freezing point was at *gr.* 25, corresponding consequently to *Fahrenheit's gr.* 32; and the heat of the cave of the observatory was *gr.* 50. which I know to be our *gr.* 53. So that the comparison is easy in the Table at N° I. IV.

4. But I know not many observations made with this Weatherglass. It is much more to our purpose to know the construction of that very remarkable one of Mr. *de la Hire*, that has stood in the Royal Observatory at *Paris* above these threescore years, and by which a register of the Weather has been constantly kept. And yet we cannot but regret, that neither Mr. *de la Hire* himself, nor any of those that succeeded him in that office, have been at the pains exactly to determine any two points of it, so as that we may be enabled to imitate it; or compare it with other Thermometers; though I hope we shall be able to trace it pretty near the truth. We are expressly told, that the Spirit in it always stands at *gr.* 48. in the

[a] Mem. Acad. Sc. 1703. p. 53.

cave

cave of the obſervatory [a]; correſponding by this to *gr.* 53. in *Fahrenheit*'s. And when it freezes in the fields they ſpeak of their Thermometer ſtanding in the open tower as pointing at from *gr.* 30. to *gr.* 32 [b]: ſomething below which the real degree of freezing would be. And from ſome concurring circumſtances and obſervations I reckon this would fall to about *gr.* 28, correſponding to our *gr.* 32, as in the Table N° I. V. We have an obſervation of Mr. *de la Hire* himſelf; whereby we find that his *gr.* 28. correſponded with *deg.* 51. *lin.* 6. in Mr. *Amontons*'s Thermometer [c].

5. Mr. *Amontons* made a fine ſtep to ſettle an univerſal Thermometer, had it not been for ſome inconveniences of which we had occaſion to take notice formerly [d]. In his the freezing point was at *dig.* 51, *lin.* 6, where our *gr.* 32 is; and the heat of boiling water at *dig.* 73, where *Fahren-*

[a] Mem. Acad. Sc. 1700. p. 8. 1701. p. 10. 1702. p. 5. 1703. p. 3. 1704. p. 2. 1705. p. 4. 1706. p. 3. 1707. p. 2. 1708. p. 61. 1709. p. 3. 1710. p. 141.

[b] Ibid. 1702. p. 5. 1704. p. 4. 1705. p. 4. 1706. p. 3. 1707. p. 2. 1708. p. 62. 1709. p. 3. 1710. p. 141. 1711. p. 2. [c] Mem. Acad. Sc. 1710. p. 142. [d] Eſſ. III. §. 10.

heit's

ESSAY IV. *heit*'s is at *gr.* 212. Whence they can eaſily be compared together, as in the Table N° I. VI.

6. [a] The Marquis *Poleni* gives us the reſult of a vaſt number of excellent and well made meteorological obſervations; in which the heat and cold are meaſured with a Thermometer conſtructed in Mr. *Amontons*'s way. But as his numbers are conſiderably different, I thought it well worth while to give a ſcheme too of his Thermometer in the Table at N° VII.

7. Mr. *de Reaumur* was very ſenſible of the difficulties of Mr. *Amontons*'s conſtruction, and propoſed a new and more certain way, as he thought, of making Thermometers. He determined to begin his ſcale at freezing water, and at boiling water marking *gr.* 80; dividing the intermediate ſpace of the tube into ſo many equal parts. I have on another occaſion [b] given my Reaſons for thinking he was in ſome miſtake with reſpect to both theſe two periods of heat. But as many very curious and uſeful obſervations have been made with his weatherglaſſes, it

[a] Phil. Tranſ. 421. p. 205. [b] Eſſ. III. §. 20. 21.

will

will be of ſingular uſe to find out the correſpondence of his ſcale with that of *Fahrenheit*. His boiling water heat is really only the boiling heat of weakened ſpirit of wine, coinciding nearly, as I gueſs, with *Fahrenheit*'s *gr.* 180. And as his *gr.* $10\frac{1}{4}$ is the conſtant heat of the cave of the Obſervatory [a], or our *gr.* 53, thence I find his freezing point, inſtead of anſwering juſt to our *gr.* 32 to be ſomething above *gr.* 34; as in the Table No. I. VIII.

8. On principles very like thoſe of Mr. *de Reaumur* Mr. *de l'Iſle* conſtructed his Mercurial Thermometer. But inſtead of freezing cold he began his ſcale at the heat of boiling water, and, inverting the common order, marked downwards the ſeveral degrees according to the condenſations of the contained quickſilver; and conſequently by numbers increaſing as the heat decreaſed. This, as I obſerved [b], was not in all glaſſes ſo uniform as were to be wiſhed. But as in Mr. *de l'Iſle*'s own ſtandards the freezing point is near to his *gr.* 150, coinciding with our *gr.* 32, it is eaſy to compare obſerva-

[a] Mem. Acad. Sc. 1730. p. 503. [b] Eſſ. III. §. 28.

tions by them with the degrees of heat marked in ours by the Table at No. I. IX.

9. Mr. *Crucquius* [a] in *Holland* has made many curious and accurate meteorological obſervations with an air Thermometer. In freezing water the whole volume was 1070, in boiling water 1510; ſo as to render it very eaſy to collate his Thermometer with *Fahrenheit*'s by the Table, No. I. X.

10. The moſt common Thermometers in *England* are thoſe made (and commonly very careleſly made) after the Standard one kept in the Royal Society. And many faſhioned on this plan by order of the Society have been ſent into foreign parts to eſtabliſh a correſpondence of obſervations concerning the weather in different countries. For which reaſon it is the more incumbent on us to find out the principles of its conſtruction, ſo as to enable us to compare it with other Thermometers. The ſcale begins, or *gr.* 0 is marked at the top, I know not well upon what grounds, and thence the numbers increaſe downwards as the heat de-

[a] Phil. Tranſ. N. 381. p. 4.

creaſes.

creaſes. [a] In it it is ſaid to be *Extreme hot* about the top of the ſcale, *Hot* at *gr.* 25, *Temperate* at *gr.* 45, and *gr.* 65 is marked as the *point of freezing*. But by trials made with ſome Thermometers that had been adjuſted pretty exactly with the ſtandard one in the Society houſe I found that the ſpirit fell to about *gr.* 78 or 79 in thawing ſnow; near 14 degrees lower than what had hitherto been reckoned. And this increaſes the wonder ſtill more how Dr. *Cyrilli* [b] ſhould have found the freezing point at *Naples* ſo high as *gr.* 55, if his Thermometer was truly adjuſted to the ſtandard.

But to compare this Thermometer with thoſe of other people it is neceſſary to find out where they correſpond in ſome other period of heat. What is marked Hot or Temperate, *&c.* on it is indeed very equivocal. But to put an end to the uncertainty. I tried and found by experience that *gr.* $34\frac{1}{2}$ anſwered to *gr.* 64 in ours. From whence their agreement is eaſily determined for all the reſt of the ſcale as in the Table at No. I. XI.

11. Sir *Iſaac Newton* [c] ſaw very well how vague and uncertain all the Thermometers

[a] Phil. Tranſ. N. 429. p. 103. N. 433. p. 337. 339. N. 434. p. 407. [b] Ibid. N. 424. p. 336. N. 434. p. 407. [c] Phil. Tranſ. No. 270. p. 824.

ESSAY IV.

in common uſe were. And therefore he contrived a new one, which I am ſurprized has gained ſo little ground in the world, as it is ſo ſimple and ſo eaſily imitated. You but begin your ſcale at Freezing, and the diſtance from that to the heat of boiling water you divide into 34 equal parts or degrees; which, as they are large, may be ſubdivided at pleaſure. How ſuch a Thermometer anſwers to *Fahrenheit*'s is ſeen at No. I. and XIII.

12. There is a Thermometer in pretty frequent uſe in *England*, wherein they conceive the middle temperature of the air as neither hot nor cold, which therefore they mark *gr.* 0, and number both above and below; denoting by this means, as they conceive, the degrees of heat and cold of the ambient medium. It is Thermometers graduated in this way which they commonly have in their ſtoves and green-houſes for adjuſting the reſpective degrees of heat the various tender exotic plants require for maintaining their life and vigour. I do not believe that theſe Thermometers are made upon any regular or fixed principles. They commonly indeed mark freezing at *gr.* 30

under *gr.* 0. But in Mr. *Fowler*'s regulator, who furniſhes moſt of the green-houſes with them, he, on my deſiring him to try it, found that in melting ſnow the ſpirit fell to about *gr.* 34. under 0. and I found by ſome compariſons I made that his *gr.* 16 coincided *q. p.* with our *gr.* 64. So that the whole correſpondence of this with *Fahrenheit*'s Thermometer is eaſily determined, as in No. I. XII.

13. Dr. *Hales* [a] thought fit to employ a new conſtruction of a Thermometer in making his curious experiments. He began his ſcale or loweſt degree at freezing, or our *gr.* 32, and carried it up to *gr.* 100, which he marked where the ſpirit ſtood when the ball was heated in hot water on which wax ſwimming firſt begins to coagulate. In ſuch water I found *Fahrenheit*'s Thermometer point at *gr.* 142: By which the two Thermometers might eaſily be compared. But by Experience his *gr.* 100 falls conſiderably above our *gr.* 142. The reſult from collating the two Thermometers together is at No. I. and XIV. At a ſpring

[a] Veg. Stat. p. 37.

ESSAY III. head the Doctor found his to point at *gr.* 13, while ours ſtood at *gr.* 48.

14. At *Edinburgh* they have for theſe many years kept a very exact regiſter of the weather, part of which is already publiſhed in their Medical Eſſays. For which it is well worth while to find out its relation to other Thermometers: which from what the authors tell us is eaſily done. For [a] when the bulb was immerged in melting ſnow the ſpirit ſtood 8'2 inches high, the heat of the human ſkin raiſing it to 22'2 inches; ſo that the intermediate 14 was divided into inches and tenths of inches. And the heat of that perſon who graduated it I found to be *gr.* 97 in mine. From whence the compariſon at any intermediate degree of heat is very eaſy, as in No. I. XV.

15. We have heard of many other Thermometers, and of obſervations and regiſters of Weather kept by them. But they have been generally ſo ill limited and deſcribed, that they are of no manner of uſe; and to whatever purpoſe they might ſerve their authors, are to us as if they never had been.

[a] Edinb. Med. Eſſ. I. p. 8.

ESSAY

ON THE

Heating and Cooling

OF

BODIES.

ESSAY
ON THE
Heating and Cooling
OF
BODIES.

SUCH is the nature of Fire and Heat, that contiguous bodies of various degrees of warmneſs do naturally come to the ſame temperature, if inert and left to themſelves without any other intrinſic principle heating or cooling the one more than the other: The hotter body loſing, and the cooling one gaining ſome degrees of heat till they all arrive at an *equilibrium*. Thus all inert bodies placed in our Air at firſt heat or cool the particles next to them; but in proceſs of time they come all to be of the ſame temperature with it. See *Boerh. Chem.* I. p. 187. 188. 200. 281. *Muſſchenbr. Eſſ. de Phyſ.* §. 961. The times of

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ESSAY V. of bringing about such effects, or reducing immersed bodies to the state of the ambient *medium*, being different, according to their relative bulks, densities, figures, particular natures, *&c.*

2. A body very hot placed in a colder *medium* cools gradually, at first faster and afterwards slower, as any one would expect; and is fully confirmed by Dr. *Muſſchenbroek*'s experiments [a]. But he did not attempt to shew after what rule; or if it was after any regular manner that such a cooling was effected. He only affirms [b] in general from them that given quantities of heat are lost at first in shorter times, and gradually longer and longer, till the cooling be very slow, and at last the heat of the body coincide with that of the ambient air.

3. Sir *Isaac Newton*'s [c] view of this matter is vastly pretty, though not thoroughly understood by Mr. *Amontons* [d]. Having heated a lump of Iron red hot, and with all the necessary precautions observed the de-

[a] Tent. Exp. Ac. Cim. Add. II. p. 47—57.
[b] Ibid. p. 52. [c] Phil. Transf. Abr. IV, 2. p. 3.
[d] Mem. Ac. Sc. 1703. p. 238.

grees

grees and times of the diminution of its heat when expoſed to the cold air; he ſuppoſed, and that not without a great ſhew of reaſon, that while it was cooling the quantities of heat loſt in given ſmall times would always be proportional to the heats ſubſiſting in it; reckoning the heat juſt to be the exceſs whereby it is warmer than the ambient air. So that from the beginning of its greateſt heat to the end or time when it came to the temperature of the ambient air, taking the times in an *arithmetical* progreſſion, the heats of the Iron above the heats of the air, and the decrements of theſe heats will be *continually* proportional. For if there be a ſeries of quantities proportional to their differences, theſe quantities and differences will be in a geometrical progreſſion [a]. Whence the diminution of heat in ſuch a body is like the retardation of a projected body endowed with a certain originally impreſſed force, and moving in a medium with a reſiſtance always proportional to its velocity. And the progreſs of that decreaſe of heat may be determined by what is commonly demonſtrated of bodies reſiſted in that manner [b].

[a] Newton. Princip. II. Lem. 1. p. 230.

[b] See Newton. Ibid. Prop. 2. Varign. in Mem. Ac. Sc. 1707. p. 504. &c.

4. This

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4. This I ſay is a moſt ingenious way of finding out and determining thoſe very great and burning heats which no ordinary Thermometer can bear. But then it is not to be admitted without ſome reſtriction. The hypotheſis is more mathematical than phyſical. It gives a fine and beautiful, but not a true view of nature. The heat of a body does not really decreaſe exactly in that proportion. For were that truly the caſe, the body, though continually cooling, would take an infinite time to arrive at the temperature of the ſurrounding medium [a]. Which however in fact we find to be accompliſhed in a very moderate ſpace of time. And that ſooner or later according to the original heat, ſize, denſity, or other circumſtances of the heated body, and cooling medium.

5. If you immerge a heated body in a cold air or other cold *medium*, that body will acquire a ſort of atmoſphere involving it all around, ſomething warmer than the reſt of the air, though a great deal colder than the body itſelf: ſo as that the ambient cold cannot affect the body, ſo much as if

[a] See Varign. Ibid. p. 507. 509.

it

it were quite naked and diveſted of its at- ESSAY V.
moſphere. But as this atmoſphere is warmeſt in or near the beginning, and gradually cooling along with the body, the ambient coldneſs will have a greater proportional influence towards the end than in the beginning. Whence though the body in whole takes a longer time to cool, the differential decrements will be in a proportion ſomewhat greater than its inherent quantities of heat.

6. But what way ſhall we determine the law of this decreaſe, and how far it may deviate from the general and more ſimple law of thoſe decrements being proportional to ſuch inherent quantities of heat? I will not inſiſt on any ſpeculation as ſufficient to lead us to this. But we may truſt to experience as our beſt guide. Obſervations carefully made and judiciouſly applied will undoubtedly bring us into the right path, or at leaſt very near it. Now as the reſult of many obſervations I find that the decrements of heat may be looked on as partly equable, and partly in proportion to the ſubſiſting heats; reckoning, as in the former hypotheſis, theſe heats to be the exceſſes whereby the heat of the body is warmer than the ambient

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ambient air. And consequently from the beginning to the end, taking the times in an arithmetical progression, those decrements may be resolved into two series. In the one, and that for ordinary of much the greatest consequence, they are always in proportion to the heats themselves, and so in a geometrical progression, as in the general theory: while in the other series, indeed the least material, the decrements are as the times, or always uniform, that is equal quantities of heat lost in equal times. And so the law of this decrease of heat coincides with the law of the retardation of a heavy body ascending perpendicularly in a medium which resists it in proportion to its velocity[a].

7. To illustrate this by observation, I chose chiefly to employ Dr. *Musschenbroek*'s experiments; as having been carefully enough done, and not liable to the objection that might be started against mine, as if they had been made with a design to be subservient to particular rules and theories. Though indeed it was the Observations that led me to think of any such rules taking place.

[a] See Newton. Ibid. Pr. 3. Varign. Mem. Ac. Sc. 1708. p. 175. &c.

In

In a ſmall bar of Iron. Muſſchenbr. Tent. Acad. Cim. Add. II. p. 48.

The Times	Degrees of Heat loſt, by Obſervation.	Degrees of Heat loſt, by the firſt conſideration.	Degrees of Heat loſt, by the 2d conſideration.	Degrees of Heat loſt, according to calculation	The Differences.
′					
1	62′5	59′4	1′2	60′6	—1′9
2	106	99	2′4	101′4	—4′6
3	128′6	125′7	3′6	129′3	+0′7
4	148′8	143′6	4′8	148′4	—0′4
5	161′8	155′6	6	161′6	—0′2
6	170′4	163′6	7′2	170′8	+0′4
7	176′5	169	8′4	177′4	+0′9
7½	180	171	9	180	0

In a ſmall bar of Steel. *Ibid.* p. 49.

′					
1	61′4	56′1	0′5	56′6	—4′8
2	94	95′2	1	96′2	+2′2
3	120	122′4	1′5	123′9	+3′9
4	141′5	141′4	2	143′4	+1′9
5	158′4	154′6	2′5	157′1	—1′3
6	167′7	163′8	3	166′8	—0′9
7	174′7	170′2	3′5	173′7	—1
8	179	174′7	4	178′7	—0′3
9	182′6	177′8	4′5	182′3	—0′3
10 q.p.	185	180	5	185	0

In

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In a ſmall bar of Copper. *Ibid.* p. 50.

The Times.	Degrees of Heat loſt, by Obſervation.	Degrees of Heat loſt, by the firſt conſideration.	Degrees of Heat loſt, by the 2d conſideration.	Degrees of Heat loſt, according to calculation	The Differences.
′					
1	76	71'4	0'8	72'2	—3'8
2	124'5	115'8	1'6	117'4	—7'1
3	141'2	142'2	2'4	144'6	+3'4
4	160'5	158'7	3'2	161'9	+1'4
5	171'6	168'8	4	172'8	+1'2
6	179'2	175'1	4'8	179'9	+0'7
7	184'4	178'9	5'6	184'5	+0'1
$7\frac{2}{15}$	185	179'3	5'7	185	0

In a ſmall bar of Braſs. *Ibid.* p. 51.

′					
1	120	114'1	1'5	115'6	—4'4
2	187	185	3	188	+1
3	232'6	228'7	4'5	233'2	+0'6
4	260'8	255'8	6	261'8	+1
5	280'2	272'6	7'5	280'1	—0'1
6	291	283	9	292	+1
7 q.p.	300	289'5	10'5	300	0

In

In a ſmall bar of Lead. *Ibid.* p. 51.

The Times.	Degrees of Heat loſt, by Obſervation.	Degrees of Heat loſt, by the firſt conſideration.	Degrees of Heat loſt, by the 2d conſideration.	Degrees of Heat loſt, according to calculation.	The Differences.
1	125	114	0'1	114'1	—9'9
2	177	174'6	0'2	174'8	—2'2
3	208	207	0'4	207'4	—0'6
4	225	224'3	0'5	224'8	—0'2
5	234	233'5	0'6	234'1	+0'1
6	239'1	238'4	0'7	239'1	0
7	241'7	241	0'8	241'8	+0'1
8	243'2	242'4	0'9	243'3	+0'1
8¾	244	243	1	244	0

In a ſmall bar of Tin. *Ibid.* p. 52.

1	61'4	61	0'5	61'5	+0'1
2	96'6	96'2	1	97'2	+0'6
3	120	116'5	1'5	118	—2
4	132'7	128'1	2	130'1	—2'6
5	139'1	134'8	2'5	137'3	—1'8
6	142'4	138'7	3	141'7	—0'7
6⅘	144	140'6	3'4	144	0

ESSAY V. In a little Mercurial Thermometer, heated to *gr.* 108, and expoſed to the open air, I found the heat decreaſe in this order.

The Times	Degrees of Heat loſt, by Obſervation.	Degrees of Heat loſt, by the firſt conſideration.	Degrees of Heat loſt, by the 2d conſideration.	Degrees of Heat loſt, according to calculation	The Differences.
0½	13	13'6	0'4	14	+1
1	25	24'1	0'8	24'9	—0'1
1½	34	32	1'2	33'2	—0'8
2	40	38'1	1'6	39'7	—0'3
2½	45'5	42'8	2	44'8	—0'7
3	49'5	46'4	2'4	48'8	—0'7
3½	52'5	49'1	2'8	51'9	—0'6
4	55	51'2	3'2	54'4	—0'6
4½	56'5	52'8	3'6	56'4	—0'1
5	58	54	4	58	0

8. The decimals of degrees are calculated and ſet down as they aroſe in the Arithmetical reduction of the numbers: Not that I would be thought to pretend to an imaginary exactneſs either in my experiments, or thoſe copied from Dr. *Muſſchenbroek*. Meaſures and obſervations of this kind admit but of an approximation to geometrical truth. All our machines are imperfect. The conſtruction of Dr. *Muſſchenbroek*'s Pyrometer made with toothed wheels, pinions,

ons, &c. could not, as he himſelf confeſſes [a], move with ſuch a regularity as were to be wiſhed; and perhaps too the heated or cooled bodies are not quite homogeneous [b], and ſo ſometimes make the refrigerations go on in ſtarts: and accordingly in the regiſter of his obſervations we meet with ſtarts, ſtops, and irregularities that in ſuch compound engines and imperfect bodies are unavoidable. And ſo we are to take the Medium and main drift of the obſervations, in the main agreeing very well with the theory, tho' they may differ ſome degrees on one ſide or t'other.

9. From this law of the Decreaſe of Heat in bodies expoſed to the influence of an equable ſtream of cooling air we ſhall be able with a tolerable degree of exactneſs to find out the intenſity of thoſe great burning fiery heats which cannot be meaſured by any Thermometers yet known. The Heat of metals red hot, or even in fuſion, of burning ſtones, melted glaſs, &c. may by this means be determined. For when they are brought to the propoſed heat by a ſtrong fire we are carefully to obſerve the

[a] Tent. Exp. Acad. Cim. Add. II. p. 29.
[b] See Ibid. p. 30. 31. 32.

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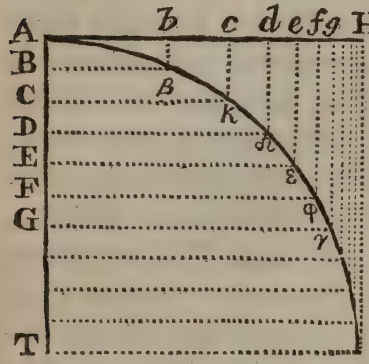
times of their cooling; and by applying a Mercurial Thermometer to them as ſoon as it can well bear their heat, we may accurately enough determine the decrements of Heat below that period; and from thence, riſing upwards in a regular ſeries, be able to find out the degrees of heat from that to the very beginning of its cooling, or the moment it was taken from the fire.

10. I am very well aware that this law I have propoſed of the Decreaſe of Heat will not always hold exactly in all circumſtances. If the heated body be very large, and without a free ventilation of air, it will acquire a warm and almoſt ſtagnating atmoſphere around it, which increaſes and ſpreadeth wider for a conſiderable time after the beginning of the obſervation, and then gradually is diminiſhed and drawn into nothing at the end or expiration of Heat. By which means it neither cools ſo faſt, nor in ſuch a regular manner, as if a conſtant briſk ſtream of freſh air were perpetually blowing along it. In thoſe circumſtances it will be difficult, if not impoſſible to reduce the decreaſe of Heat to a regular ſeries of numbers; however even in this caſe, as well as

in the former more regular decline of Heat, we may be able to find a method of tracing its ſeveral degrees in all its different periods of time, and exhibit them to the eye as diſtinctly, or rather more ſo, than if they were expreſſed in numbers; and that too in a ſort of geometrical way.

11. Let the time the body takes in cooling be expreſſed by the line AT, the quantity of heat loſt (being its exceſs above the heat of the ambient medium) by AH drawn perpendicular to it. AT being divided into any number of very ſmall equal parts AB, BC, CD, *&c.* gives AB, AC, AD, *&c.* the times from the beginning increaſing in an arithmetical progreſſion. And in AH the lines Ab, bc, cd, *&c.* are ſuppoſed to expreſs the decrements of Heat in theſe reſpective ſmall times. So that Ab, Ac, Ad, *&c.*



ESSAY V. Ad, &c. are the quantities of heat loſt from the beginning of the obſervation at any aſſigned moment of time, and HA, Hb, Hc, &c. the Heats ſtill ſubſiſting at the reſpective times A, b, c, &c. Now from B, C, D, &c. draw the lines Bβ, Cκ, Dδ, &c. parallel to AH: and from b, c, d, &c. draw bβ, cκ, dδ, &c. parallel to AT, ſo that they meet reſpectively in β, κ, δ, ε, &c. and through theſe points of concourſe draw the curve Aβκδε, &c. this curve line, being concave towards AT and convex towards AH will be the Curve of the Decreaſe of Heat. AT may be lookt on as its Axis, AB, AC, AD, &c. as the Abſciſſes, and Bβ, Cκ, Dδ, equal to Ab, Ac, Ad, as its Ordinates. And I find this curve to be a ſort of Hyperbola. So that from any given ſeries of obſervations of the decreaſe of Heat of any body we ſhall be able to protract upon paper, or to calculate any other way, as much of this Hyperbolick line, as to enable us to find its Center, Diameters, Aſymptots, &c. and to draw it out to what length we pleaſe: and from thence to inveſtigate the Heat of the body at any determined diſtance of time before we had acceſs to know the Heat by a Thermometer.

meter. By which method then, only from obſerving the decrements of Heat in a lump of Iron, or any other intenſly hot body, after it is able to bear the application of a Thermometer, having taken particular notice how ſoon it comes to that temperature; we may determine its degree of Heat the moment it was taken burning hot from the furnace. We may either calculate backward the ſeries of numbers found out by obſervation, or protract on paper mechanically the Hyperbolic line or ſcale of the Decreaſe of its Heat in the manner juſt now propoſed. For either of theſe ways will give us the initial greateſt Heat it had when taken from the fire with tolerable exactneſs. The former will be ſufficient, if the hot body be very ſmall, or a ſtream of cool air be conſtantly blowing along it; but the other will be more convenient if the ſurrounding air be in a ſtate of ſtagnation or nearly ſo.

12. We ſee then from the firſt moment of the cooling of bodies the quantities of heat loſt in given times are always growing leſs and leſs; till the heat and conſequently theſe decrements of heat quite evaniſh, and the body put on the temperature of the am-

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bient medium; and all this in a pretty regular manner. The heating of bodies does not go on in such an orderly way; concerning which we have some very nice experiments furnished us by the ingenious and accurate Professor *Musschenbroek*[a]: from which he justly infers that the expansion or heating of bodies is not equable, but very slow at first, as if the fire had some difficulty in its first penetration of the body: which gradually grows easier, the expansions or increments of heat in given times soon coming to be very considerable. These in a very little time come to their greatest height. And then such increments gradually diminish till they quite evanish, the heated body acquiring the temperature of the ambient medium[b]. All which I have likewise found to be true by the experiments I have made on this subject. Some of which I shall soon have occasion to insert.

13. That bodies cool or heat sooner or more leisurely according to their different bulks, densities, figures, *&c.* is commonly taken notice of. There will be no great

[a] Tent. Exp. Acad. Cim. Add. II. p. 24—28. 34—43.
[b] Ibid p. 29—32. 39.

labour

labour required to convince every man that will but think of it, that a given quantity of the ſame ſort of matter will be eaſier or more difficultly cooled or heated, as it is expanded under a greater or ſmaller ſurface; and conſequently muſt vary according to the different figures wherein it is ſhaped. Thus bodies of a round form as having the greateſt quantity of matter within the leaſt ſurface are, *cæteris paribus*, the ſloweſt in heating or cooling, and ſo on of the other figures of bodies, according to their compactneſs or expanſion.

14. As to their difference of ſize, no body makes any doubt of great bodies altering their temperature more ſlowly than ſmaller ones: "Quo minor eſt corporis "moles, ſays Lord *Verulam*[a], eo citius per "corpus calidum approximatum incaleſcit:" But in what proportion to their bulk is not altogether ſo eaſy to determine. Let us however hear what Sir *Iſaac Newton*[b] ſays on the ſubject. "Globus major calorem "diutius conſervaret in ratione diametri, "propterea quod ſuperficies (ad cujus men-

[a] Nov. Org. II, 13. §. 40. [b] Princ. Math. p. 509.

"ſuram

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" ſuram per contactum aëris ambientis re-
" frigeratur) in illa ratione minor eſt pro
" quantitate materiæ ſuæ calidæ incluſæ.—
" ſuſpicor tamen quod duratio caloris, ob
" cauſas latentes augeatur in minore ratione
" quam ea diametri: & optarim rationem
" veram per experimenta inveſtigari."

15. To ſatisfy this great man's wiſhes I began to make ſome experiments of this ſort, which I propoſed to have carried on farther if I had had leiſure enough. However from the trials I made I think we have good reaſon to conclude his ſpeculation of the faculties to preſerve heat being proportional to the diameters of ſimilar bodies to be very juſt. And that his ſuſpicion of that faculty in the greater bodies not being fully in ſuch a high proportion as the diameters is without ſufficient ground.

16. I took two *China* bowls pretty nearly of the ſame ſhape but of very different ſizes, the large one being about twice as broad, and ſo of the other longitudinal dimenſions, as the other, and conſequently holding eight times more liquor. Into the big one A I put two quarts, and into the other B two gills

gills of water, which in both was brought to the temperature of *gr.* 112. by very nice Thermometers placed in each; and immediately removed into a cool place, where there was a moderate current of air of the temperature of about *gr.* 48 or 49; and the refrigerations of the waters carefully obſerved in the following times.

Degrees of Heat.	Times in A	Times in B: By obſervation.	Times in B: By theory.
	′	′	′
gr. 112	0	0	0
104	$10\frac{1}{2}$	$5\frac{1}{2}$	$5\frac{1}{4}$
96	$21\frac{1}{4}$	11	$10\frac{5}{8}$
80	$54\frac{1}{2}$	28	$27\frac{1}{4}$
72	81	42	$40\frac{1}{2}$
64	118	61	59
56	194	99	97

The ſame day the experiment was tried over again, but in a place where the ſurrounding air had no current, and little other agitation than what was occaſioned by the motions I made in carrying on the obſervations. The reſult was as follows.

Degrees

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Degrees of heat.	Times in A	Times in B	
		By observation.	By theory.
	′	′	′
gr. 112	0	0	0
104	10	6	5
100	16	9	8
96	23	12½	11½
92	31	16	15½
88	40	21	20

The Thermometer in the little bowl was ſomewhat above *gr.* 112 in the beginning; which was the cauſe of the times of the falling to ſuch and ſuch degrees of heat to be always about a minute longer than the theory required. There was ſomething though leſs of this too in the foregoing experiment. And making a due allowance for theſe ſmall and truly inconſiderable variations the theory coincides ſurpriſingly with obſervation: nearer indeed than we could well expect in ſuch experiments, wherein the Inſtruments muſt be allowed not to come up to a mathematical exactneſs. A very ſmall and inſenſible error in the conſtruction of the Thermometers, or a very inconſiderable miſtake, as of about a quarter or half a degree in making the obſervation, would ſeemingly

ſeemingly occaſion a very ſenſible difference between the time actually obſerved and that which the theory required.

To try it in bodies differing ſtill more in bulk from one another, the heat of the air being *gr.* 48 there were two veſſels filled, the one with one gill and the other with 27 gills of water; their reſpective diameters thus being 1 and 3; and the refrigerations came out in this order.

Degrees of heat.	Times in A	Times in B	
		By obſervation.	By theory.
	′ ″	′ ″	′ ″
gr. 108	0 00	0 : 00	0 : 00
104	5 : 20	1 : 30	1 : 46
100	10 : 00	3 : 20	3 : 20
96	15 : 45	5 : 05	5 : 15
92	22 : 10	7 : 10	7 : 23
88	30 : 00	9 : 00	10 : 00
84	39 : 00	11 : 15	12 : 20
80	48 : 20	14 : 00	16 : 07
76	57 : 00	17 : 30	19 : 00
64	101 : 00	33 : 10	33 : 40

There ſhould be more experiments tried; and theſe on other bodies as well as water; on ſolids as well as fluids, and in a greater variety of proportions of their reſpective bulks, and with bodies immerſed in various mediums,

mediums, *&c.* all which I am apt to think would come out, like to what we have already tried, agreeable to Sir *Iſaac*'s rule.

17. Let us next enquire if the ordinary theory of bodies heating and cooling faſter or ſlower as they are leſs or more denſe will come out as conformable to nature and truth. It is indeed a very plauſible ſpeculation, and what one would be apt to deduce from the *vis inertiæ* of matter that rare bodies are ſoon either heated or cooled, but that denſe bodies are more ſlowly altered by the heating or cooling influence of the ambient *medium*. [a] "Suſpicamur (naturam Denſi & "Rari) poſſe habere conſenſum cum tarda "& celeri exceptione & depoſitione Calidi "& Frigidi. Fiat igitur experimentum, "ſi rarius corpus non admittat, & amittat "calorem aut frigus celerius, denſius vero "tardius." "Quo denſiora corpora," ſays Dr. *Boerhaave* [b], "ſive fluida fuerint ſive "conſiſtentia, eo pluri tempore egent, ut "ab eodem igne æqualiter incaleſcant." And in like manner as to the cooling of bodies he tells us [c], "corpora—acceptum caloris gra-

[a] Bacon Hiſt. Denſ. &c. p. 17.
[b] Chem. I. p. 279. vid. & p. 266. [c] Ibid. p. 264.

" dum tanto diutius conſervare quo ſunt denſiora, ponderoſiora, aut plus ſubſtantiæ corporeæ habentia." In a word, " quo " denſa magis corpora eo diutius impreſſi " calidi tenacia [a].—Tanto pluri tempore " egent ut poſſint redire ad temperiem cum " rarioribus citius refrigerandis [b]." ESSAY V.

This rule of bodies requiring times of heating and cooling in the order and proportion of their denſities is, I ſay, a very plauſible ſpeculation, and to which every body at firſt hearing is ready to aſſent. And moreover this propoſition, ſo obvious in theory, is ſaid to be confirmed too by experiments, as we find them propoſed by Dr. *Boerhaave* [c]. " Multa ſuper hac re cogi- " tanti" (ſays he) " *obſervatum* certe id " fuit, eo citius caleſcere ab eodem igne cor- " pus quo rarius fuerit; eo lentius autem " refrigerari calefactum ſemel, quo denſius " fuerit, eo citius refrigeſcere quo rarius " erat.—Si vas aëre plenum, aliud aqua, " utrumque dein eidem calori exponitur, " erit forte aër ſic calidus millies rarior aqua " quoque ita calida, ſed aqua conceptum " tanto tardius calorem tanto diutius retine-

[a] Ibid. p. 160. [b] Ibid. p. 267. [c] Ibid. 200.

" bit,

ESSAY V. " bit, ut aër forte millies citius refrigeſ-
" cat.— [a] Sit vas cavum, parallelepipedum,
" ſupra apertum, ex aëre, aqua repletum;
" cui imponantur vaſa cylindrica vitrea,
" æqualia; repleta ad eandem altitudinem
" diverſis pondere liquidis; dein ſupponatur
" ignis, ut aqua intra hoc vas aſſidue mota
" æquabiliſſime incaleſcat, cernemus nudo
" oculo liquidum livius, adeoque rarius,
" citiſſime expandi, denſius vero multo len-
" tius; quin & thermoſcopia impoſita idem
" docebunt. Caleſcit ocyſſime aër, dein
" Alcohol, Oleum Petrolei liquidiſſimum
" poſtea, tum Oleum Terebinthinæ, mox
" Aqua pura, dein Aqua ſalſa, Lixivium
" fortiſſimum, Metalla, Mercurius, Au-
" rum." And as to their cooling he gives us a ſimilar experiment, and with a like ſucceſs. [b] " Si enim in aqua ebulliente di-
" verſa pondere corpora æqualiter inde ca-
" leſcunt, id diutiſſime calidum manebit
" quod ponderoſiſſimum, id citiſſime friget
" quod leve. Quouſque autem hactenus
" per experimenta procedere datur regula
" fere generalis hæc habetur; vacuum Tor-
" ricellianum calorem in eo genitum uno
" momento amittit. Aër calefactus in olla,

[a] Ibid. p. 279. [b] Ibid. p. 264.

" citiſſime

" citiſſime calorem conceptum perdit. Al-
" col lentiore gradu. Aqua diutius quam
" Alcol. Argentum Vivum tardius vero
" eodem calore refrigeratur. Ita inter ſo-
" lida quoque, lignum, ſaxum, metalla,
" iterum æqualiter calefacta, retinent quæ-
" ſitum calorem exacte tanto ſerius." This ſcheme of bodies having a faculty of preſerving their temperature in proportion to their reſpective denſities, is illuſtrated from ſundry conſiderations by Dr. *Muſſchenbroek*[a], who reckons them up in this order[b]. Air, Alcohol, Petroleum, Oil of Turpentine, Rapeſeed Oil, Diſtilled Vinegar, Water, Salt Water, Aqua Fortis, Oil of Vitriol, Spirit of Nitre, Quickſilver.

18. I know no ſtronger inſtance than this of the weakneſs, or, if I may venture to ſay ſo, of the preſumptuouſneſs of the human underſtanding, in pronouncing too haſtily concerning the nature of things from ſome general preconceived theories. That rule of bodies acquiring given degrees of heat or cold *cæteris paribus*, in times juſt reciprocally proportional to their denſities, tho' plauſible enough in theory, I cannot find to be

[a] Eſſ. de Phyſ. §. 969. [b] Ibid. §. 944.

ESSAY V. true in fact. Air indeed is heated and cooled ſooner than any other fluid I have had opportunity of trying, though not in ſuch a different proportion as its extreme rarity, compared with the great denſity of other fluids, would require. And Water is ſlower of heating and cooling than either Oil or Alcohol: but, contrary to all our fine theory, Quickſilver, the moſt denſe ordinary fluid in the world, excepting only melted Gold, is however the moſt tickliſh next to Air; it heats and cools ſooner than Water, Oil, or even rectified Spirit of Wine itſelf.

Taking about 15 ounces of Mercury, and $\frac{1}{14}$ of this weight of Water, ſo that their volumes were pretty equal, I put them into two very thin glaſſes of the ſame ſize and make, with a Thermometer in each: and after letting them ſtand a good time in the cold air, till both Thermometers pointed preciſely *gr.* 46, I ſet them down at the ſame time almoſt cloſe to one another, before a great fire at a conſiderable diſtance from it, but ſo that the heat ſhould equally act upon them. And in the following times the Thermometers (which in themſelves were very like one another, and equally

qually tickliſh) ſhewed the reſpective fluids to be heated in the following order.

Times	Water heating	Mercury heating
0 or begin.	*gr.* 46	*gr.* 46
3	51	56
6	57	66
9	62	73
12	66	78
15	70	82
18	73	84
21	76	86
24	77½	86½
27	79	87
30	80	87
33	80½	87
36	81	87
39 The fire	82	88
42 ſtirred.	84	90
45	85	92
48	87	93—
51	87½	93+
54	88	93+
57	88½	93+
60	89	93

Then the Water and Quickſilver being both brought to the ſame temperature of *gr.* 89 were at the ſame time ſet down in an open window, where the temperature of the air was at *gr.* 52; and the two Ther-

ESSAY V. mometers ſhewed the fluids to cool in this order.

Times	Water cooling	Mercury cooling
0	*gr.* 89	*gr.* 89
3	$85\frac{1}{2}$	$81\frac{1}{2}$
6	82	76
9	79	72
12	76	68
15	$73\frac{1}{2}$	65
18 A blaſt	$70\frac{1}{2}$	$61\frac{1}{2}$
21 of air.	68	$59\frac{1}{2}$
24	66	58
27	$64\frac{1}{2}$	57
30	63	56
33	62	$55\frac{1}{2}$

Here we ſee that Water, inſtead of acquiring or loſing a given quantity of heat 13 or 14 times ſooner than Quickſilver, as it ſhould do by the common theory, is about twice ſo ſlow in heating and cooling than what Mercury was found to be. Could the glaſſes have been made any thinner, perhaps the Mercury would have appeared to cool ſtill ſomething more quickly. And as the fire did not act equally all the while you find too ſome little anomalies occaſioned thereby.

As

As this experiment differed so widely from the common opinion, and from what every body, to whom I have had occasion to propose it, expected, I tried it over again with the same cautions, but with larger volumes, taking near 48 ounces of Mercury, and $3\frac{1}{2}$ ounces of Water; their quantities being to one another as $13\frac{1}{2}$ to 1; and so their volumes pretty equal. And the result of the observation was as follows.

Times	Water heating	Mercury heating
0 or beginning.	*gr.* 48	*gr.* 48
4	52	58
8	$57\frac{1}{2}$	69
12	63	78
16	68	$84\frac{1}{2}$
20	$72\frac{1}{2}$	$89\frac{1}{2}$
24	77	$92\frac{1}{2}$
28	80	95
32	83	$96\frac{1}{2}$
36	85	97
40	87	98
44	89	99
48	91	100
52	$92\frac{1}{2}$	100
56	$93\frac{1}{2}$	100
60	94	$99\frac{1}{2}$

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They were both reduced to the heat of *gr.* 92, and then carried into the air of the temperature of *gr.* 51, and cooled in the following order; all the while the Water evaporating a little, and ſticking in drops to the ſide of the glaſs.

Times	Water cooling	Mercury cooling
0 or beginning.	*gr.* 92	*gr.* 92
4	88	85½
8	85	80½
12	82	76
16	79½	72½
20	77	69½
24	75	67
28	73	64½
32	71¼	62½
36	69½	61
40	68	59½
44	66¾	58¼
48	65½	57
52	64½	56¼
56	63¾	55¼
60	62¾	54½
64	61¾	54
68	61	53½

19. As Oil is more tenacious than Water, many are apt to think that it will be ſlower both in admitting the particles of heat and fire, and in cooling or letting them

them go. "Omnes Philoſophi," ſays Dr. Boerhaave [a], "cenſerent olei tenacitate ir-"retitum ignem longe diutius in oleo hæ-"ſurum." And another theory will lead them to a new opinion: when they conſider that Oil, conſiſting chiefly of ſulphureous particles, will therefore, from their notion of the Newtonian obſervations of the rays of Light and Heat, be more apt both to attract and retain the heat applied to it. But how weak and fallacious are all our ſpeculations concerning the nature of things not thoroughly well underſtood. Dr. *Boerhaave*, in direct oppoſition to this laſt theory, makes Water both heat and cool more ſlowly than Oil; and that exactly in proportion to their reſpective denſities. [b] "Bina vaſa æqualia accepi, quorum unum "aqua, oleo implevi olivarum alterum. "Ambo repoſui in vaſe, in quo feci ebul-"lire aquam, retinui in illa ebulliente aqua, "donec certus eſſem utroſque liquores eo-"dem bullientis aquæ gradu æque cale-"factos; exemi tum ex eo vaſe, repoſui in "eodem ambo aëre, ut viderem tempus, "quo uterque liquor reducebatur ad eun-"dem refrigerationis gradum; atque in-

[a] Chem. I. p. 263. [b] Ibid.

ESSAY V. "veni, pro ratione ponderis comparati, "prorſus æquale." Nor this did I find exactly true. Oil did indeed both heat and cool faſter than Water: and, contrary to all the theories, even much faſter than its difference in ſpecific weight ſhould have made it. Oil of Olives is but about $\frac{1}{10}$ lighter than Water: but it is heated and cooled faſter in a much greater proportion. That exceſs is not indeed always the ſame, or near the ſame. It does not ſhew ſuch an uniformity of difference as Quickſilver did. In the beginning there is no great difference; then Water takes about $\frac{1}{4}$ or ſo more time in acquiring or loſing given quantities of heat than what the Oil does: but in the progreſs of the experiment, the difference becomes always greater and greater, till towards the end the Water is almoſt twice as ſlow in heating and cooling as Oil, taking the times from the beginning of the obſervation; as in the following experiments.

Times

Times	Water heating	Oil heating
0 or beginning.	*gr.* 50	*gr.* 50
8	54	54
16	63	66
24	71	78
28	75	83
32	79	88
36	82	93
40	85½	96½
44	88	99½
48	91	102
52 the fire decaying.	94	105
56	96	107
60	99	109
64	101	110½
68	103	111½
72	104	111½
76	104½	111½

And both being brought to the temperature of *gr.* 108, they were set in the air of between *gr.* 50 and 51, and they cooled in this order.

Times

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Times	Water cooling	Oil cooling
0 or beginning.	*gr.* 108	*gr.* 108
4	104	102
8	100	96
12	96½	90
16	94	86
20	91½	81½
24	88½	77½
28	86	74
32	84	72
36	82	70
40	81	68
44	79½	66½
48	78	65
52	76½	63½
56	75	62½
60	74	61½
68	71½	60
76	69½	58½
84	67½	57½

The experiment of the heating and cooling of Oil was repeated with the following ſucceſs.

Times

Times	Water heating	Oil heating
0 or beginning.	*gr.* 45	*gr.* 45
4	45½	46
8	49	50
12	52½	55½
16	57½	62
20	61½	69
24	65	74
28	68½	78½
32	71½	82½
36	74½	86
40	77	88½
44	79	90½
48	81	93
52	83	95
56	84½	96
60	86	97
64	87	98
68	88	98½
72	89	99
76	91	100½
80	92	102
84	93½	103
88	94½	103½
92	94¾	103¾
96	95	104

Both the Water and Oil were brought to the heat of *gr.* 96, and placed in a large room, the temperature of which was about *gr.* 45; and they cooled in this order.

Times

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Times	Water cooling	Oil cooling
0 or beginning.	*gr.* 96	*gr.* 96
4	92	90
8	89	85
12	86	80
16	83½	76½
20	81½	73
24	79½	70
28	77½	67½
32	75½	65½
36	74	63½
40	72½	61½
44	71	60
48	69½	58½
52	68	57½
56	67	56½
60	66	55½
68	64½	54
76	62¾	52¾
84	61¼	51¾
92	59¾	51
100	58½	50½
116	56	49
132	54	48
148	52½	47½
180	50¾	46½
212	49	45½
244	47¾	45¼
276	47	45
340	46	45

20. The

20. The heating and cooling of Water and Rectified Spirit of Wine came out as follows. ESSAY V.

Times	Water heating	Sp. Wine heating
0 or beginning.	*gr.* 52	*gr.* $52\frac{1}{2}$
4	53	54
8	$56\frac{1}{2}$	$59\frac{1}{2}$
12	61	$65\frac{1}{2}$
16	65	71
20	69	76
24	73	81
28	77	85
32	80	88
36	83	91
40	$85\frac{1}{2}$	$93\frac{1}{2}$
44 The fire	88	96
48 decaying	90	$97\frac{1}{2}$
56	$92\frac{1}{2}$	$99\frac{1}{2}$
60	94	100
64	95	100

They were both brought to the heat of *gr.* $95\frac{1}{2}$, and expoſed to the open air of the temperature of *gr.* 57 or 58, where they cooled in this order.

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Times	Water cooling	Sp. Wine cooling
0 or beginning.	gr. 95½	gr. 95½
4	91½	90½
8	88	86
12	85	82½
16	82½	79
20	80	75½
24	78	73
28	76	71
32	74	69
36	72½	68½
40	71	67
44	70	66¼
48	69	65½
52	68	64
68	65	62
84	62½	60½

Thus we ſee that Spirit of Wine both heats and cools faſter than Water; and that in a much greater proportion than the inverſe *ratio* of their ſpecific weight does require, as we obſerved likewiſe of Oil. But ſtill Quickſilver, however denſe, is more tickliſh and eaſier affected by heat and cold than any of theſe fluids. Common Brandy, upon trial, I did not find to differ ſenſibly from Water in this reſpect.

21. The

21. The ſame theory, drawn I ſuppoſe from the general doctrine of the *vis inertiæ* of Matter, led Dr. *Boerhaave* [a], and Dr. *Muſſchenbroek* [b] to lay it down as a principle that the faculty of cooling other bodies was in proportion to the denſity of the cooling medium. "Corpora, ſays *Boerhaave*, "quæ ignem jam in ſe continent copia "majore, quam ambientia fluida, vel vi- "cina corpora, illum ignem amittunt eo "citius, quo in fluidum denſius immittuntur "refrigerandi cauſa. Quod ita intellectum "velim. Sit Aër, Aqua, Argentum Vi- "vum, in Vaſis, ejuſdem accurate tempe- "riei in omnibus his. Eſto tum igniti ferri "fruſtum triplex æquale perfecte ignitum. "Unum horum trium relinquatur in Aëre "notatæ temperiei, immergatur ſecundum in "Aquam accurate tam frigidam quam Aër "hoc tempore. Tertium vero intrudatur "in Argentum Vivum etiam æque frigi- "dum ac priores, Aër & Aqua. Quid "fiet? in raro Aëre ferrum diu retinebit "ſuum calorem, in Aqua citius amittet, "in Argento Vivo citiſſime. Et quidem "videtur in illa aqua fere tanto refrigerari

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[a] Chem. I. p. 267. [b] Eſſ. de Phyſ. §. 967.

ESSAY V. " citius, quanto hæc aëre denſior; adeoque " octingenties ocyus. In argento vivo forte " quaterdecies citius, quam in aqua.

22. Neither does this ſpeculation come out true in fact. The times of bodies cooling in theſe different fluids do by no means differ ſo much as is commonly imagined. Inſtead of 800 a body cools but about 8 times faſter in Water than in Air. And the refrigerating virtue of Quickſilver was found inſtead of 14 times greater than that of Water to be a very ſmall matter ſo, as about 2 ſeconds, or ſo in a minute.

Air, Water, and Quickſilver, being all brought to the common temperature of *gr.* 52, I placed ſucceſſively in theſe ſeveral fluids a ſmall Thermometer that had always been heated to *gr.* 112; and carefully obſerved the times wherein it loſt 56 degrees of heat, or wherein the Mercury ſunk to *gr.* 56 on the ſcale, which was within 4 degrees of the heat of the ſurrounding *mediums*. And by four different trials the refrigerations came out thus

	′ ″	′ ″	′ ″	′ ″
In Air	8:45	8:30	8:20	8:25
In Water	1:04	1:03	1:04	1:04
In Quickſilver	1:00	1:03	1:01	1:02

23. This

23. This doctrine of the heating and cooling of bodies in all its ſeveral branches ſhould be carried on by a variety of experiments, which I have neither leiſure nor opportunity of proſecuting at this time. So that I muſt leave it to others, whoſe ſituation is more favourable for making the neceſſary obſervations for eſtabliſhing and perfecting that doctrine, to which I have only been able to furniſh ſome helps.

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AN

ESSAY

Towards a

Natural and Experimental HISTORY

Of the

Various Degrees of Heat in BODIES.

St. Andrew's 1738, 1739.

AN ESSAY

Towards a Natural and Experimental HISTORY Of the Various Degrees of Heat in BODIES.

I. *Of the way of computing the different degrees of Heat.*

ESSAY VI.

MANY of the ancients had ſtrange notions of the nature of Heat. They ſuppoſed it in different ſubjects to differ in kind as well as quantity. They talked very magnificently of the Celeſtial Heat, as differing much in its nature from the Heats commonly produced on our earth. And theſe too they thought to be of quite different natures in the different bodies wherein they are lodged. The Heat of the fire,

ESSAY VI. or of hot water, or of fermenting ſubſtances, they thought of a lower kind, and altogether diſtinct from the Heat of animals. And this too they diſtinguiſhed into natural and præternatural or morbid, as ſorts of Heat quite different from one another. And thoſe too they reckoned of different natures in the different ſpecies of animals. Doctrines and ways of ſpeaking of this ſort ſet up by the Peripatetic ſchool, and too much adopted by *Galen*, and the Phyſicians after him, continued long in the world; and were alſo countenanced by the Chymiſts, theſe *philoſophi per ignem*, who profeſſed, and valued themſelves on a more than ordinary knowledge of the ſecrets and operations of Heat.

2. *Gomez Pereira*, who was among the firſt that dared to think freely in Philoſophy as well as Phyſic, ventured to affirm [a] all Heat, whether of an elementary, igneous or animal kind, to be of one and the ſame nature; that the Heat of the ſun, or any other elementary Heat, did not differ from that of animals but in degree; and that the

[a] Nov. Med. cap. II. p. 7, 9. cap. III. p. 12, 17, 20, 23, 24, 25.

Heat

Heat of a man in a fever differed only by its exceſs from that of a man in health; and that the Heats of other animals did not differ ſpecifically, but only in quantity, from one another, or from that of the human kind. ESSAY VI.

3. The learned *Teleſius*, though he was ſenſible of the great variety of the degrees of Heat in Bodies, thought that the determining them and aſcertaining their differences to be almoſt impoſſible. So that he declines taking the trouble of any ſuch inquiry. "Qui calor," ſays he[a], "vel quantus, & quæ ejus copia, & quæ entia in qualia invertat minime inquirendum videtur, ut quod homini nulla, ut nobis videtur, innoteſcere queat ratione. Quî enim vel caloris vires, & calorem ipſum veluti in gradus partiri, vel materiæ, cui inditus eſt, copiam quantitatemque diſtincte percipere, & certis determinatiſque caloris viribus copiæque in certam materiæ quantitatem, dipoſitionemque certas actiones; & certæ materiæ quantitati certam determinatamque caloris copiam aſſignare liceat?

[a] De Rer. Nat. 1, 17.

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The purſuit however of all this he recommends to others, as being in itſelf of very great conſequence. " Utinam id alii & " perſpicaciori præditi ingenio, & quibus in " ſumma tranquillitate rerum naturam per- " ſcrutari licuerit aſſequantur; ut homines " non omnium modo ſcientes, ſed omnium " fere potentes fiant." So fond would he have been of the ways of meaſuring Heat found out ſince that time. Though for his own ſhare he abſolutely deſpairs of doing it, eſpecially with any tolerable accuracy. " Nobis ut ingenue fateamur craſſiore in- " genio donatis, & quibus non niſi extre- " mum vitæ ſpatium philoſophari licuerit, " minimeque id moleſtiis, curiſque vacuis " —ſatis ſit, ſi qui quantuſque calor, quam " molem, qua donet diſpoſitione intueri li- " ceat. Et non exquiſite id quidem, di- " ſtincteque, ſed rudiore & confuſo quo- " dam modo, nec ſingulas caloris differen- " tias, quæ innumeræ & roboris & copiæ " ſunt; nec materiæ conſpiſſationes diver- " ſitatemque percipere potentibus, ſed per- " paucas utriuſque & confuſe illas, indi- " ſtincteque."

4. The

4. The nature of Heat my Lord *Verulam* seems to have considered with more than ordinary attention; and gives his doctrine *de forma calidi* [a], by way of example for managing philosophical subjects. And he found all the various heats not to differ in kind, but in their various intensities, durations and other modifications and accidents [b].

5. *Sanctorio*'s Thermometer, given out to the world about that time, shewed all kinds of Heat to have a similar effect in dilating the air; according to whose various expansions, the various intensities of those Heats of whatever kinds were to be judged. The same was soon found to hold in other fluids. And at length the firmest bodies themselves were, by undeniable proofs, found to swell by the application of Heat of any sort. And from the various degrees of those dilatations alone we must take our measures of the various degrees of Heat in Bodies.

[a] Nov. Org. II. 11. 12. 13. 18. 20. [b] Ibid. p. 189. 196. 197. 200. 206. 208. 220. 252. 253. 254.

6. But

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6. But where ſhall we begin to reckon the Heat of Bodies, or their greateſt natural contractions, or the limits of Heat and Cold? Many things, when firſt propoſed, look ſingular and odd, that, after laying aſide prejudices, and by mature conſideration become familiar and eaſy; and of the truth of which we come at length to be fully ſatisfied. We commonly conceive water, when once frozen and turned to ice, to have loſt all Heat, and ſo to have become abſolutely cold; on which account many Philoſophers did too haſtily begin their reckonings of Heat from this point. But as various fluids, ſuch as melted wax, melted tallow, oil, wine, brandy, &c. loſe their fluidity at various degrees of Heat, and after that may ſtill grow colder and colder in their firm ſtate; juſt ſo after water begins to freeze, we know from many conſiderations it can become ſtill much colder. That is, that in freezing water there is ſtill a conſiderable quantity of Heat; which by degrees grows leſs and leſs, till the cold becomes intolerable to us mortals; as in the dead of winter in the northern intemperate climates, where men cannot

cannot live without more than ordinary shelter from the extreme severity of the weather. The air is oftentimes as much colder than water beginning to freeze, as such water is colder than our summer weather. We reckon it warm when the fluid in the Thermometer is raised to *gr.* 64, it is at *gr.* 32 when water freezes; and such colds have been often seen as to bring it down to *gr.* 0, the beginning of the scale, nearly the cold produced by a mixture of snow and salt.

7. Not as if this was the lowest degree of Heat, or the greatest degree of Cold that nature has ever been observed to produce on our earth, as Dr. *Boerhaave* [a] seems to think; and which he [b], though I know not on whose testimony, tells us was the greatest cold that was observed in *Iceland* in the cold winter of $170\frac{8}{9}$. The cold has been sometimes felt as great, or near as great as this in climates ordinarily temperate enough; and certainly much warmer than what we have reason to believe the bleak cold country of *Iceland* to be. At *Ger-*

[a] Chem. I. p. 162. 164. 166. 399. 400. 593.
[b] Ibid. p. 158. 166. 174.

manopolis

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manopolis in *Pensylvania*, only in the latitude 40°, *an.* $173\frac{1}{2}$ the cold brought the Mercury to *gr.* 5 [a]. In the famous winters $170\frac{8}{9}$ and $171\frac{5}{6}$, the cold at *Paris* was such that it would have brought down the Mercury in our Thermometer to *gr.* 8 [b]. At *Leyden an.* $172\frac{8}{9}$ it sunk to *gr.* 5 [c]; and at *Utrecht* it fell a division lower [d]. At *London* in the winters $170\frac{8}{9}$ and $173\frac{9}{1}$ the cold was so violent as to bring the spirits almost down to the artificial cold of an ice and salt mixture [e]. And *an.* $170\frac{8}{9}$ Mr. *Roemer* [f] at *Copenhagen* in the latitude of 55° 43′ found the Mercury in his Thermometer to fall fully thus low, to wit to *gr.* 0 *.

[a] Act. Berolin. Cont. IV, p. 130. [b] Mem. Acad. Sc. 1710. p. 186. 1717. p. 3. [c] Boerh. Chem. I, p. 158. [d] Musschenbr. in Phil. Transf. 425. p. 359. [e] Derham in Phil. Transf. Abr. IV, 2. p. 113. VI, 2. p. 50. [f] Vid. Boerh. Chem. I, p. 720.

* Dr. Boerhaave speaks of this remarkable observation of Mr. Roemer as made at Dantzick. But I rather think it to have been made at Copenhagen. Dr. Derham (see Phil. Transf. Abr. IV, 2. p. 114.) had papers in his hands giving an account of this very frost *an.* $170\frac{8}{9}$ at Copenhagen, said to be taken from the observations of Mr. Roemer. And Mr. Roemer was a Dane, lived and bore high offices at Copenhagen; and died there *an.* 1710. However in the main this does not at all alter the story with respect to us.

8. But

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8. But if we go farther north, though not so far as *Iceland*, we shall meet with much greater colds than any thing ever seen in these countries. In *January* 1732 the cold was so great at *Upsal*, that it brought the spirit of wine in one of the Royal Society's Thermometers down to *gr.* 124, which falls about a degree below *gr.* 0 in *Fahrenheit*'s. And at *Petersburg* in the latitude only of 59° 56′, much the same with that of *Upsal*, *an.* 1733, the cold was so excessive that Quicksilver was by it contracted $\frac{1}{50}$ part of the bulk it had in boiling water, or to fall to *gr.* 200 in *De l'Isle*'s Thermometer [a], which brings it to —*gr.* 28 in ours. We know in general from the accounts of travellers what intense colds rage in winter in many places of the world, and especially in or near the frigid zones in both hemispheres. But we have few observations on record exactly limited or reduced to a determined measure. However in M. *De Maupertuis*'s [b] accurate journal we find that the French Academicians, who in pursuit of knowledge, and

[a] Phil. Trans. 441. p. 222.
[b] Fig. de la Terre p. 58.

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to determine that important queſtion of the figure of the earth, wintered *ann.* $173\frac{6}{7}$ at the north polar circle, experienced a degree of cold much greater than any thing we find meaſured and recorded by others. At *Torneao* in the latitude of 65° 51′, even on this ſide that circle, their ſpirit of wine Thermometers came at length to be frozen, and a mercurial one conſtructed in Mr. *de Reaumur*'s way ſunk to *gr.* 37 under his freezing point; which would have been about 33 diviſions below *gr.* 0 in *Fahrenheit*'s. When that intenſe cold was ſuddenly admitted into their warm rooms, their bodies could hardly ſuffer it, their breaſts were as if they had been rent, and the moiſture of the air was in an inſtant converted into whirls of ſnow. This is a degree of cold as much below the cold of freezing water, as that is below the ordinary heat of our ſkin. For it is $33+32=65$ diviſions below the freezing point at *gr.* 32, and the heat of the human ſkin at *gr.* 97 is juſt ſo much above it.

9. To find a cold ſo far below that of freezing water is certainly very ſurprizing. And yet a greater than this almoſt inconceivable

ceivable degree of cold may by art be procured in leſs rigid climes. For we can contrive a method of cooling much beyond the ordinary tendency and courſe of nature. Many things when mixed together immediately become vaſtly colder than formerly when they ſubſiſted diſtinct from one another. Spirit of nitre poured on beaten ice or ſnow brings on a very intenſe cold. Theſe, when their temperature and that of the air was but about *gr.* 32 above *gr.* 0, the ingenious and induſtrious *Fahrenheit* by an artful management cooled ſo much that the mercury in the Thermometer ſunk to —*gr.* 40, or 72 diviſions below the freezing point [a]; a degree of cold greater than what was felt in the neighbourhood of the polar circle. And this is as much below the cold of freezing water, as that is below the heat of our hotteſt animals, or of men in fevers. No body would have thought *a priori* that freezing ice was capable of ſuch an additional quantity of cold.

10. Nor are we abſolutely ſure that yet in theſe circumſtances all heat was de-

[a] See Boerh. Chem. I, p. 162. Muſſchenbr. Tent. Exp. Acad. Cim. Ad. p. 174.

ſtroyed.

ESSAY VI. ſtroyed. Even in that horrid and moſt bitter cold at *Torneao*, which the *French* Mathematicians mention with ſo much horror, we are ſure there was; and likewiſe even in that exceſſively cold mixture of *Fahrenheit* there might ſtill be, and probably there was, ſome degree of Heat. What if there was a concourſe of ſuch frigorific circumſtances? If *Fahrenheit*'s experiment were to be made in the frigid zone, what would be the effect, and what a dreadful cold might by that means be produced? * So then for want of knowing the ultimate limits of heat and cold we cannot determine the geometrical proportion of the real or abſolute quantity of the Heat

* When I was lately at Paris there were put into my hands ſome very extraordinary obſervations communicated to the Royal Academy of Sciences by Mr. De l'Iſle at Petersburg, of exceſſive colds at Kirenga in Siberia, a place, not very far north neither, lying in the latitude only of 58° 10′. There in the winter 1738 the mercury once fell to *gr.* 275 in De l'Iſle's Thermometer, which by calculation I find ſhould be *gr.* 118 below the beginning of the ſcale in ours. This (if there be no miſtake in the affair) is the moſt aſtoniſhing thing I ever met with of the kind. It ſuppoſes a cold 150 degrees below the freezing point, almoſt an incredible thing: a cold as much below the cold of freezing water, as this is below the heat of boiling ſpirit of wine.

of

of one Body to that of another. All we ſhould pretend to is to aſſign their arithmetical differences; which is a very uſeful work, and is to be done by a great number of accurate obſervations on the various expanſions of bodies by the various degrees of heat: theſe expanſions always correſponding in ſome meaſure to the quantities of fire or heat applied. So that we ſhall in the ordinary way ſpeak of theſe things as proportional to one another. Though I would not be underſtood poſitively to affirm that they both go on always preciſely in the ſame ratio: or that the expanſions were always exactly in a ratio neither greater nor leſs than the ſimple ratio of the quantities of the applied heats.

11. When people[a] tell us that red hot iron is 3 or 4 times hotter than boiling water; and that boiling water is about 3 times hotter than the heat of our ſkin, or of the ſummer heat, they generally reckon the loweſt limits of heat to be where water begins to freeze; and thence found the additional dilatations of quickſilver, or of lin-

[a] Vid. Newton Princip. p. 508. & in Phil. Tranſ. Abr. IV, 2. p. 2. 3. Pitcarn. El. Med. II, 1. §. 26.

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ſeed oil (or of any other fluid that may be uſed in ſuch Thermometers) to be in theſe proportions: though the abſolute or real quantities of heat in theſe bodies do not differ ſo much by far, as they by that miſtaken way of reckoning computed. Thus boiling water indeed raiſes the mercury in the Thermometer to *gr.* 212, that is 180 diviſions above *gr.* 32, the heat of freezing water, while the heat of the human body is but about *gr.* 97 or 98, only 65 or 66 degrees above the freezing point. And therefore the dilatation acquired from that point by the heat of boiling water, to the dilatation acquired by the heat of our body, is in the proportion of 180 to 66, or 2'73 to 1; which is ſomething leſs than triple. But the real heats of theſe things are ſtill leſs differing from one another. Suppoſe for example *Fahrenheit*'s ice and ſpirit of nitre mixture of—*gr.* 40 had been at the loweſt boundary of heat (though there is great reaſon to think that to be ſtill much lower) and then we ſhall find that the heat of boiling water ſhould be to that of our bodies only as 212+40 to 98+40, or 252 to 138, or 1'83 to 1: that is not ſo much as double. Who before ſuch a particular

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ticular examination would have thought the burning deſtroying heat of boiling water not to be altogether twice ſo great as the ſoft temperate heat of a man in health? And upon the former reckoning of red hot iron, its heat ſhould be to the heat of our ſkin inſtead of 10 or 12 to 1, only as about 700 to 138, or 5 to 1. So that by thus bringing down the limits of heat at leaſt 72 degrees below the ordinary reckoning, we find its various characters as *froſt*, *temperate*, *warm*, *tepid*, *boiling water*, *red hot iron*, &c. whatever their arithmetical diſtances come out to be, are not ſo different in their real proportions to one another, as is commonly ſuppoſed. Though on the other hand I would not affirm them to differ ſo little as Mr. *Amontons*[a] reckoned. In whoſe ſcheme the air ſhould intirely loſe its elaſticity, when it is perfectly devoid of heat (of which however I think we are not well aſſured) and then in ſuch a total abſence of heat, were it poſſible to procure it, reducing his numbers to ours, the mercury in *Fahrenheit*'s Thermometer ſhould fall 431 diviſions below the

[a] Hiſt. Acad. Scienc. 1702. p. 8. Mem. 1703. p. 63. 64. 238.

ESSAY VI. cold of freezing water, or to—*gr.* 400 q.p. a degree of cold as much below the heat of the human body, as that is below the burning heat of oil or mercury boiling. But as we are not quite certain about this loweſt degree of heat, we muſt, as I juſt now ſaid, content our ſelves to obſerve the arithmetical differences of the various degrees of Heat in Bodies, though we ſhould not be able to determine their real or abſolute proportions, until we ſhall acquire a farther inſight into the nature of things than we have at preſent. It is good to know the narrow limits of our faculties, and modeſtly to confeſs the bounds of our knowledge: ever keeping in mind that excellent axiom of the Lord *Verulam*[a], "Homo naturæ miniſter & interpres tantum facit & intelligit quantum de ordine naturæ *opere* vel *mente* obſervaverit: nec amplius ſcit aut poteſt." It muſt be by this road of experience and obſervation, pointed out to us by the great Lord Chancellor, if ever we arrive at a higher degree of knowledge than what we at preſent enjoy.

[a] Nov. Org. I, 1.

II. *Of the Heat of the Air.*

12. In our ſearch [a] after the loweſt degree of Heat, though we could not arrive at it, we found however in ſome ſeaſons and parts of the world exceſſively great, and as it were monſtrous degrees of cold; and which the inhabitants of the earth can ſcarcely bear; they are intolerable both to animals and vegetables. The quarters of the earth, within the polar circles, were thought by the Ancients to be uninhabited by reaſon of the exceſs of cold prevailing there, ανοικητοι δια ψυχος [b].

Frigus iners illic habitat, pallorque, tremorque,
Ac jejuna fames.

"Quia," (ſays *Macrobius* [c],) "torpor ille "glacialis nec animali nec frugi vitam "miniſtrat."

Pigris ubi nulla campis
Arbor æſtiva recreatur aura [d].

[a] §. 6.——10. [b] Diog. Laert. VII, 156. [c] In Somn. Scip. II, 5. p. m. 110. [d] Horat. Carm. I, 22.

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And indeed these bleak wild parts of the world, though not quite waste, are but thinly peopled. And no wonder. There, and in other disadvantageously situated places, where such intolerable colds chiefly rage, men must shelter themselves in clothes and houses. The beasts of these countries are many of them provided by nature with a thick warm covering; or must retire the best way they can from the killing colds of winter, which however often overtake them. The very vegetables themselves would die were they not commonly in these seasons buried under snow to such great depths, as the extreme severity of the cold cannot reach. In bitter black frosts we often experience the fatal effects of the want of this shelter and protection, even in the humbler tribe of vegetables. And though there be plenty of snow, the trees and higher shrubs, that are not covered by it, are great sufferers in the extraordinary severe winters, even in the more happy and otherwise more temperate countries. As has been often seen, and in our own days was experienced through all Europe in the years 1708, 1728;

$172\frac{3}{9}$, &c. [a]; when the Thermometers pointed these low degrees of heat we had formerly occasion to mention.

13. But these and such like excessive colds are in these parts of the world justly looked on as a sort of irregularities, and out of the ordinary course of things. In these temperate climates of ours the mercury seldom falls under *gr.* 16. And even then it is extraordinary cold. And indeed we are apt to reckon it very cold at *gr.* 24. By the very construction of the Thermometer it is slight frost at *gr.* 32: and continues coldish to *gr.* 40, and a little above it.

14. The middle temperature of our atmosphere in these countries is about *gr.* 48, when we cannot call the weather either hot or cold; and is as it were a medium of all the seasons; coinciding pretty nearly with the middle vernal and autumnal heat, as observed in *England* by Sir *Isaac Newton*, and Dr. *Hales*, and by Mr. *Crucquius* in *Holland*. The *French* raise this middle

[a] Phil. Transf. Abr. IV, 2. p. 120, &c. Mem. Ac. Sc. 1710. p. 186. Hales Veg. Stat. p. 74, &c.

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temperature a little higher. They reckon it equal to the heat of the cave of their royal obſervatory: and this, both by obſervation, and a calcul, comparing it with Mr. *Amontons*'s Thermometer, I find to be at *gr.* 53 in *Roemer*'s. And indeed this middle temperature of the air we may eaſily conceive to be very different in different countries. It is to be reckoned as a relative ſort of thing, varying according to the various climates and conſtitutions of bodies in them, which by uſe come to be fitted to different temperatures. In the cold countries the air will be found agreeable enough to the inhabitants while it is betwixt *gr.* 40 and 50. In theſe middle climates in our neighbourhood, and not too far ſouth of us, we are beſt pleaſed with the Heat of the Air from a little under *gr.* 50 to *gr.* 60; while in the hot countries they have their air generally, and can well bear it ſomething both above and below *gr.* 70.

15. When the heats in the reſpective climates are either much higher or much lower than theſe, both men and beaſts are fain to provide againſt them the beſt way they can. In the cold they ſhelter themſelves

ſelves in houſes, dens, holes of the earth, &c; and the human kind beſide that provide for themſelves clothes and fires, to protect them from the ſeverity of the weather. In the heats we lay aſide our clothes, or take to the lighteſt ſort; we ſhun the mid-day air, and retire to the cooleſt places; for in the day time it is generally warmer in the open air than in houſes. And ſome of the bird kind chooſe to ſhift their country in the different ſeaſons of the year, finding always by this means a temperate enough climate for their conſtitution.

16. But the ſame degree of heat is not equally fitted to all animals. Some kinds naturally chooſe a cold country, while others indulge themſelves in a warmer climate, and find that better fitted to their conſtitutions. And ſo too, though with Dr. *Hales* [a] we ſhould deem the moſt genial heat for the generality of plants to be from *gr.* 53 to *gr.* 69, the various claſſes of vegetables have their various temperatures of the air in which they can thrive beſt. Every body knows that ſome plants can live only in the cold countries, being burnt up if tranſ-

[a] Veg. Stat. p. 59.

planted

ESSAY VI. planted to a more ſouthern ſoil; while the natives of the warm countries are chilled to death with us, if not very carefully and artfully protected from the injuries of our ſeverer weather. This piece of culture, propoſed long ſince by the great Lord *Verulam* [a], has been, in our time, carried to a ſurprizing height. With the help of Thermometers we can ſo adjuſt our ſtoves, green-houſes and hot-beds, as to imitate the temperature of any climate we pleaſe; and to ſupport and keep in ſtrong life and vigour the plants, which nature has given only to the warmer countries. According to the obſervations of the *London* gardeners, as marked on Mr. *Fowler*'s Thermometer reduced to ours, I find the kindly degrees of heat for ſome of the moſt curious foreign plants to be theſe. For the Myrtles *gr.* 44; Oranges *gr.* 47; Ficoides *gr.* 50; Indian Fig *gr.* 53½; Aloe *gr.* 57; Cereus *gr.* 60; Euphorbium *gr.* 63; Piamento *gr.* 66; Ananas *gr.* 60; Melon Thiſtle *gr.* 73.

Not as if theſe plants could bear only ſuch and ſuch preciſe points of heat. They,

[a] Nov. Org. II, 35. p. 254. 50. p. 348. Nat. Hiſt. 401. 405. 412. 856.

like

like other vegetables and animals, have a considerable latitude that way; and can suffer the air both colder and warmer than these degrees, which however are reckoned most adapted to their nature. Though I suspect some of them are marked too low, being far under the ordinary and most kindly heats in these countries where such plants naturally grow. But there indeed they have a freer and opener air; where consequently they can bear greater heats than in our smothered and pent up stoves and greenhouses.

17. Even we in this country do not reckon the air warm till it arrives at about *gr.* 64. It is to us very warm and sultry at *gr.* 80. And Dr. *Boerhaave* [a] thought it naturally scarce ever exceeded *gr.* 80 or 90 at most, reckoning such hot air would soon be destructive of the life of animals. But sometimes even in these temperate climates the weather has been found much hotter. I find observations recorded of the weather at *Utrecht*, *Paris*, *Padua*, &c. having sometimes been observed so hot, as that the mercury in our Thermometer

[a] Chem. I, 156. p. 192. 207, 213, 274. 278. 553.

would

ESSAY VI. would have been raiſed to above 90 degrees. In *Penſylvania*, no intemperate climate neither, the heat in ſummer 1732 came once to be *gr.* 96 or 97 [a]. And Mr. *de Reaumur* [b] promiſes us obſervations of heats that people were obliged to ſuffer, though they reached to *gr.* 38 in his Thermometer, or near *gr.* 104 in ours. Even in the more northernly countries, where the ſun has leſs influence, we can by art contrive a method of giving undeniable evidence of animals being able to bear a ſtill greater warmneſs of air. In the outer bagnio at *Edinburgh* the heat uſed to raiſe our Thermometer to *gr.* 90; where, though at your firſt entry it ſeemed indeed a great deal too hot, and ſomething diſagreeable, yet ſoon it became ſo very tolerable, that one might without any uneaſineſs have continued in it as long as he had thought fit. Yea one could ſtay ſome hours in the inner bagnio, though the heat there uſed to be about *gr.* 100.

18. From all this we ſee how finely every thing has been contrived and adjuſted

[a] Act. Berolin. Cont. IV, p. 131.
[b] Mem. Acad. des Sc. 1736. p. 486. 489.

by the great and wiſe Author of nature; and what a vaſt latitude of the heat and cold of the air the animal body, eſpecially that of man, can bear, from the ſultry burning heats, as hot or hotter than his blood, down to the chilling colds a good deal below that of freezing water. Though indeed it is about ſome intermediate diſtance betwixt them, where the heat is moſt agreeable, or beſt tempered to the bodies of animals and vegetables.

19. And it was only the middle climates or temperate zones that many of the Ancients imagined were habitable by us mortals.

Mortalibus ægris
Munere conceſſæ divûm [a].

"In his," ſays *Macrobius* [b], "tantum "vitales auras natura dedit incolis carpere." And accordingly much was ſaid long ago of the intolerable heat of the torrid zone, as by that means uninhabitable by men, ανοικητος ὑπο καυματων [c]. Whence *Ovid* [d]

[a] Virgil. Georg. I, 237. [b] In Somn. Scip. II, 5. p. m. 110. [c] Stoicks in Diog. Laert. VII, 156. [d] Metamorph. I, 49.

ſpeaking

ſpeaking of the zones of the earth, ſays

Quarum quæ media eſt non eſt habitabilis æſtu.

Virgil [a] ſays the ſame thing in a more pompous manner.

Quarum una coruſco
Semper ſole rubens, & torrida ſemper ab igni.

And *Horace* [b], with his ordinary poetical imagery, ſuppoſes himſelf placed

Sub curru nimium propinqui
Solis, in terra domibus negata.

But *Tibullus* [c] expreſſes the poſition of this part of the earth, and its conſequences, more fully than any of them in theſe lines.

Media eſt Phœbi ſemper ſubjecta calori.
Non ergo preſſo tellus conſurgit aratro:
Nec frugem ſegetes præbent, nec pabula terræ.
Non illic colit arva Deus, Bacchuſve, Cereſve,
Nulla nec exuſtas habitant animalia parteis.

[a] Georg. I, 234. [b] Carm. I, 22. [c] Eleg. IV, 1. in Meſſal.

But

But this opinion was, I humbly think, among their vulgar errors, received chiefly by the people, and taken up by the poets as a beautiful fiction, which we cannot well ſuppoſe they really believed. The wiſer ſort, though they ſometimes ſpoke [a] like other folks, knew better things. Their hiſtorians and geographers have recorded tolerable good accounts of ſome of the middle parts of the earth within the tropicks. *Æthiopia*, *Arabia Felix*, the ſea coaſts of *India*, the iſle of *Taprobana*, *Ophir*, *Tarſhiſh*, &c. were heard of even by the common people, all well inhabited, though lying within the torrid zone. And the travels of the Ancients, as well as ours, ſhewed theſe countries not to be diſagreeable or inconvenient for human life. Nay the heats there are by no means ſo exceſſive as we are all, before trial, ready to imagine and expect. The Jeſuits miſſionaries to the *Eaſt-Indies* [b] took particular notice of this. And their capacity of obſerving ſuch things,

[a] See Cicer. Somn. Scip. 6. Macrob. in Somn. Scip. II, 5. 6. 7. Diog. Laert. VII, 156.

[b] See Du Hamel. Hiſt. Ac. Sc. p. 272. 273. Hiſt. Acad. Sc. 1666——1698 II, p. 111. 112. Mem. Acad. Sc. 1666——1698. VII, p. 835.

and

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20. It is true all theſe obſervations were made in iſlands, and on or near the ſea coaſts, which we may preſume to be ſomewhat cooler than the inland countries [b]. But ſtill we are well aſſured that even theſe can eaſily enough be born with. And all theſe parts of the world have that advantage of the weather there being much more uniform than with us. Their air ſuffers much ſmaller changes both in the incumbent weight of the atmoſphere preſſing it, and in the degrees of heat wherewith it is warmed. Dr. *Halley* [c] tells us that he, as well as others [d] who have ſojourned within the

[a] Mem. Ac. Sc. 1733. p. 580, &c. 1734. p. 759, &c.
[b] See Mem. Acad. Sc. 1666——1698. VII, p. 837.
[c] Phil. Tranſ. Abr. II, p. 18. 20. 22.
[d] Vid. Mem. Ac. Sc. 1666——1698. VII, p. 840.

tropicks,

tropicks, found very little variation in the height of the mercury in the Barometer, which we know to be 2 or 3 inches in the more northern regions. And we are all but too ſenſible, and we had but juſt now occaſion to take notice of the vaſt changes of the temperature of the air in this quarter of the world; which through the whole year is commonly found ſo equable in the torrid zone. At *Siam* within the lat. 15°, from the greateſt winter cold to their higheſt ſummer heat the Jeſuits experienced a difference only of 26 degrees in *Hubin*'s Thermometer [a]; the extent of which I believe differs not much from the like number in ours. [b] In *Batavia*, though a very hot place, and in *gr.* 6. ſouth lat. the exceſs of heat above the greateſt cold was ſtill ſomething leſs. And in *Malacca* [c] but 2 degrees of latitude from the equator, the weather is very temperate, and ſo equable, that for 7 months together the ſpirit in the Thermometer was never under *gr.* 60, nor above *gr.* 70. [d] In the iſle of *Bourbon*, in the latitude about 22°, the difference between the higheſt and loweſt afternoon heat in a twelve-

[a] Du Hamel Hiſt. Ac. Sc. p. 272. [b] Ibid. p. 273.
[c] Ibid. [d] Mem. Ac. Sc. 1734. p. 762.

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month's time was but 8 divisions in *De Reaumur*'s Thermometer, which make up scarcely 15 in ours. And the ordinary difference of the night and day heat in these climates was found a small matter compared to what we have it commonly with us [a]. And as the torrid zone excels our countries hereabout in a more equable degree of heat and weight of the atmosphere, so we are more happily appointed that way than in *Sweden* and *Lapland*, and these other northern regions [b]. From whence it would seem a general rule that, *cæteris paribus*, the greatness of the vicissitudes of the air increases with the latitudes of the places as you go from the æquator.

III. *Of the comparative Heats of the Sun, Earth, Planets and Comets.*

21. We have hitherto considered the air, though influenced by the Sun, as shaded from its immediate burning operation. For in the open air exposed to its direct beams shining with greatest advantage the heat is

[a] Ibid. 1666—1698. VII, p. 837. 1733. p. 537.
[b] See Phil. Trans. Abr. II. p. 22. Maupert. Fig. de la Terre. p. 72.

found

found much higher than any thing we have hitherto been ſpeaking of. And an examination of this will naturally lead us into the conſideration of the Heat of the Sun, the inexhauſtible magazine of light and fire, the great furnace of our ſyſtem; and to conſider its influence on bodies placed at different diſtances from it.

Sir *Iſaac Newton* [a] comparing the Sun's influences on the Earth and Mercury, which by its vicinity to the Sun ſhould have ſeven times more heat from him than we, reckons the ſolar heat in that planet ſufficient to boil our water, and quickly carry it all off in vapour; having found by a Thermometer that water was boiled by a heat ſeven times greater than the heat of the ſummer Sun; which then in this reckoning ſhould be only at *gr.* $(32+\frac{180}{7}=)58$. But this expreſſion of *the heat of the ſummer's Sun* muſt be greatly modified to be conſiſtent with the true ſtate of things. He muſt not only have meant it ſolely of the degrees above freezing water (as was then the faſhion of thinking and ſpeaking) but alſo inſtead of *ſummer Sun*, he muſt really have underſtood *the ordinary ſhaded air in ſum-*

[a] Princip. III. Prop. 8. Cor. 4. p. 406.

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mer, or *the ſummer heat of the air*, as Dr. *Pitcairn* [a], (who I ſuppoſe had his obſervations of this matter from Sir *Iſaac*) expreſſes it. Though I muſt confeſs that this could be but very improperly compared to the ſolar heat at Mercury; except we ſuppoſe that he likewiſe meant the heat in the ſhade at Mercury too. And farther it will be reckoned an incongruous way of judging of the Heat of the Sun by taking our meaſures from its impaired action on the air ſcreened from its direct rays.

22. The direct ſummer mid-day heat is vaſtly greater than ſuch a low allowance; it having been found, even in theſe northern climates, able to dilate the fluid in the Thermometer much more than $\frac{1}{7}$ of the dilatation cauſed by boiling water. Dr. *Boerhaave* is the loweſt in his reckoning of any that pretended to take an eſtimate of it, ſaying [b] that the greateſt heat ever produced by the direct action of the Sun in our air, or other bodies heated by it, ſeldom reaches to *gr.* 84. And at another time [c], though he raiſes it a little higher, ſeeming to allow

[a] Elem. Med. II, 1. §. 26. [b] Chem. I. p. 213.
[c] Ibid. p. 156.

that

that the great dog-day heat may come to *gr.* 90, he thinks it can ſcarce ever go beyond theſe bounds, or arrive at the heat of the human body. But Sir *Iſaac* himſelf in another place of his book [a] expreſsly tells us that he found the heat of boiling water only about three times greater than the heat communicated to dry earth by the ſummer Sun. And ſo too Dr. *Muſſchenbroek* [b] reckoned it probable that the heat of boiling water is three times greater than the greateſt heat communicated to bodies by the ſummer Sun in his country; by theſe reckonings this heat amounting to *gr.* $(32 + 1\frac{8}{3} =) 92$. Nay even in *Italy Borelli* [c] and *Malpighi* [d] found this heat of the Sun in midſummer only equal to the heat of the *viſcera* of hot animals, I ſuppoſe about *gr.* 102; not a great deal higher than what *Newton* and *Muſſchenbroek* reckoned.

23. All this may, I believe, commonly be juſt and true enough. But it is not ſo univerſal, either as to times or places, as one would be ready to expect from ſuch

[a] Princip. p. 508. [b] Tent. Exp. Ac. Cim. Add. II. p. 22. [c] De Mot. Anim. II. Prop. 96. 221. [d] Op. Poſth. p. 30.

ways of ſpeaking. The Lord *Verulam* [a] long ago took notice that the higheſt degree of animal heat ſcarce ever attained to the heat of the Sun's rays in the ſcorching climates and ſeaſons. And even in this cold country at ſome times I have experienced greater Heats of the Sun; and ſo might any body elſe that would attend to it have done. Many have had occaſion to obſerve how vaſtly metals are heated in the Sun. Sir *Iſaac Newton* [b] takes particular notice of this; I have in this place in the latitude of 56° 20′ ſeen a piece of iron heated ſo much that I could not hold it in my hand above a few ſeconds of time; and therefore it was much hotter than my blood. And I have oftener than once ſeen dry earth heated to above *gr.* 120. And Dr. *Hales* [c] found a very hot ſun-ſhine heat *an.* 1727 ſtill greater, *viz.* at about *gr.* 140. And Dr. *Muſſchenbroek* [d] in his later trials once experienced it ſo high as *gr.* 150. So that reckoning from the freezing point at *gr.* 32 in the common way, theſe ſtrong ſun-ſhine heats were much greater than $\frac{1}{3}$, or even the half of the heat of boiling water. And

[a] Nov. Org. II, 13. p. 192. [b] Princip. p. 420.
[c] Veg. Stat. p. 59. [d] Eſſ. Phyſ. §. 974.

in the more ſouthern countries it has been found ſtill greater at ſome particular times. Much has been ſaid of the ſcorching and intolerable heat of the Sun in the torrid zone. [a] We have many ſtrange ſtories of extraordinary ſummer heats, as great tracts of land, houſes, &c. ſet on fire, ſtones heated ſo as to melt lead, &c. Theſe indeed ſeem extravagant. But the *German* Annals [b] preſerve the memory of an exceſſively hot ſummer *an.* 1230, when they roaſted their eggs in the ſand heated by the ſun. And I have been told that in *Egypt*, by no means the hotteſt country in the world, they can often on the tops of their houſes roaſt their eggs at the ſun. And to harden the white of an egg I find the heat of about *gr.* 156 to be neceſſary. In the year 1705 the ſummer was very warm. [c] At *Montpelier* one day the Sun was ſo very hot as to raiſe the quickſilver in M. *Amontons*'s Thermometer to the mark of boiling water itſelf, which is our *gr.* 212.

[a] See Boyle Hiſt. of the Air. Abr. III. p. 55.
[b] See Lipſii Epiſt. ad. Belg. II, 91.
[c] Mem. Ac. Sc. 1706. p. 15.

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24. But after all, these great heats will be reckoned irregularities, and out of the ordinary course of the seasons; and what may be produced by the Sun only in certain times and circumstances. For in our temperate climates the most common and ordinary noontide heat of the summer Sun may be found to raise the quicksilver in the Thermometer but about 60 or 70 divisions above the freezing point at *gr.* 32; and the afternoon heat in the shade about the half of that. So the ordinary summer Sun heat with us does nearly coincide with the heat of our body; which was found [a] to be somewhat more than the half of the heat of boiling water, supposing *Fahrenheit*'s cold mixture to be the very lowest degree of heat; and so too boiling water instead of seven times, is but between two and three times hotter than our common shaded warm air at midsummer.

25. However this solar heat is still much greater in the warmer countries. And if we pretend to make any comparison of such things, it is our equatoreal heat we should

[a] See §. 11.

reckon

reckon as the Sun's true heat at our orbit, and what we ſhould collate with its influence on the other planets, or its heat at their reſpective diſtances.

26. But what on the other ſide will lower or bring down this ſolar heat very much is this conſideration, that the heat communicated by the Sun to bodies on this earth depends much upon other circumſtances beſide the direct force of its rays. Theſe muſt be modified by our atmoſphere, and variouſly reflected and combined by the action of the ſurface of the Earth itſelf, to produce any notable effects of heat. For were it not for theſe additional circumſtances I queſtion much if the naked heat of the Sun would to us be very ſenſible. We find all our great heats to be in thoſe places that lye low, and have a great height of atmoſphere above them, and ſurrounded by eminencies and riſing grounds. [a] If you aſcend on high to the tops of the very ele-

[a] See Liv. Hiſt. XXI, 32. Senec. Nat. Qu. IV, 11. Bacon. Nov. Org. II, 12. p. 169. Borell. de Incend. Aetn. p. 7. 50. Boyle Exp. on Cold Abr. I. p. 639. 658. Hiſt. of the Air. Abr. III. p. 53. 54. 55. Boerh. Chem. I. p. 172. 185. 476.

vated

vated mountains, you are chilled with cold, and you find everlasting snows, that after thousands of summers have scarce ever been thawed, though every day exposed to the direct rays of the Sun; which in some countries are darted perpendicularly on them. We hear that the *French* Virtuosi, who by order of the King went to *America* to make their observations on the figure of the earth, *&c.* found on the very high hills there just under the line such excessive colds, that it is suspected they were as intense as what were observed in *Lapland* itself. So necessary it seems is a long and direct passage through all or the greatest part of the depth of our atmosphere, or the assistance of its pressure, or the reflections of rays from the Earth's own surface, to invigorate these rays, and to give them strength for warming terrestrial bodies. To which too the particular sulphureous nature of the low parts of the atmosphere may not a little contribute.

27. So then there are other circumstances beside the vicinity to the Sun that may influence and determine its heating virtue. Thus reckoning the force of heat to be *cæteris paribus* as the density of its rays, or reciprocally

reciprocally as the ſquares of its diſtances from the central fire, the planet Mercury is ſo much nearer the Sun than the Earth, that its heat from him, by calculation of their reſpective diſtances, comes out ſeven times greater than ours [a]. And ſo would an inhabitant there feel it, if they have the ſurface of Mercury diſpoſed like that of our Earth, and an atmoſphere hanging over their heads ſo like ours, as to qualify the Sun's rays in the ſame manner. But if they have little or no atmoſphere (which ſeems to be the caſe of our moon) or an atmoſphere ſo diſpoſed as only to affect the rays of heat in the manner that the upper parts of our atmoſphere do, then it is poſſible the ſolar heat at Mercury may be as tolerable as on our Earth. And on the other hand, though we commonly reckon [b] that our waters ſhould be frozen up, and we our ſelves be chilled to death in the far off planets Jupiter and Saturn, they may, for ought we know, have their atmoſpheres and ſurfaces ſo conſtructed, as to render the ſolar heat comfortable enough even for animals and vegetables of the like nature and paſſions with our own.

[a] See Newton. Princip. III, Prop. 8. Cor. 4. p. 406.
[b] See Newton. Ibid. p. 405.

28. But

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28. But the caſe of the comets is vaſtly different from any thing we can propoſe of the other planets. Their orbits are ſo excentrical, that they muſt be very variouſly affected by the Sun in the different parts of their courſe. But yet their atmoſpheres and bodies may be of ſuch a nature as that they ſhall not be heated to ſuch a vaſt and almoſt inconceivable degree as is ſometimes ſuppoſed. In the Newtonian ſyſtem of comets [a] the diſtance from the Sun of that famous one which appeared *an.* 1680 * in its perihelion was, by calculation, to the mean diſtance of the Earth in the ratio of about 6 to 1000 : ſo that its heat in that part of its period Sir *Iſaac* determines ſhould have been to our ſummer heat reciprocally

[a] Newton. Ibid. p. 508.

* It is ſuppoſed by many to have been this very comet that appeared an. 1106, an. 531, an. A. C. 44, &c. See Newton Princip. p. 501. Halley Synopſ. of Comet. in Gregor. Aſtron. in Engliſh. p. 901. 902. 903. Whiſton New Theor. of the Earth. p. 187. 191. &c. But M. Caſſini repreſents the comet or comets an. 1680 in a very different manner from theſe authors; nor does he make that great blazing ſtar that alarmed all Europe, to have been ſo very excentrical, or to have come ſo very near the body of the ſun as they do. See Mem. Acad. Sc. 1731. p. 464—468.

as the ſquares of theſe numbers, that is as 1000000 to 36, or 28000 to 1. And therefore, ſeeing the heat of boiling water is three times greater than what dry earth acquires from the ſummer Sun, and the heat of red hot iron three or four times greater than the heat of boiling water, he computes the heat of the comet ſhould have been 2000 times greater than the heat of red hot iron. A prodigious and terrible heat, even with all the abatements we have been propoſing; and which I conceive no body can take on, that is not immenſely denſer and more fixed than any terreſtrial body we know. For from the example of common water, &c. [a] it would ſeem that all bodies are, according to their various degrees of denſity and fixedneſs, ſuſceptible juſt of ſuch and ſuch particular degrees of heat, beyond which, whatever fire be applied to them, they cannot be raiſed; though by a heat exceeding theſe their parts are all diſſipated, are rendered volatile, and fly off in vapour. And yet I cannot but take notice that all this calculation is upon the ſuppoſition that the comet was in its own nature like our Earth, and

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[a] See Boerh. Chem. I. p. 265. 248.

involved

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involved in an atmoſphere like ours: otherwiſe that method of reaſoning and analogy cannot take place; nor would the Sun's heat affect it in that way.

29. But I ſay again under another view and conſideration, what if the real ſolar heat both in itſelf, and what it can communicate to us, and other planetary bodies (while it is not concentrated by burning glaſſes, or ſtrengthened by other aſſiſtances) be vaſtly leſs than what is commonly reckoned? All the natural heat we meet with here on the earth we are ready to aſcribe to the action of the Sun, which perhaps has but a ſmall ſhare in it, overlooking a ſource of heat, which, though often ſpoke of by the Theoriſts of the Earth *, is ſeldom conſidered in that advantageous light I would chooſe to take it. We formerly took notice of what a great ſtock of heat all terreſtrial bodies are poſſeſſed, even in the

* See Empedocles in Plutarch. De Prim. Frigid. p. m. 507. Des Cartes Princip. Phil. IV, 3. Burnet Theor. of the Earth. III, 6. Woodward Eſſ. Nat. Hiſt. of the Earth. p. 135—162. 220—225. Nat. Hiſt. &c. illuſtr. &c. Introd. p. 136. 140.—143. 149—152. Whiſton New Theor. &c. p. 78. 231. 334. 447. Gaſſend. Epicur. Philoſoph. I, p. 546, &c.

coldeſt

coldeſt winters. Every body has felt or heard that the temperature of the air in mines and other places deep under ground is warm, or at leaſt very tolerable. And we know, from the niceſt obſervations, that in the cave of the obſervatory at *Paris*, only about 90 feet under ground, the heat keeps the Thermometer at *gr.* 53; and that without any aſſiſtance from the Sun; it being never ſenſibly increaſed by the moſt ſcorching ſeaſons beyond its heat in the moſt ſevere winters that have been felt there. And the ſame conſtant and unalterable degree of heat was obſerved by Mr. *Boyle* [a] in a cave cut deep into the earth. [b] And great and even troubleſom heats are ſaid to be obſerved at greater depths, and increaſing in proportion to theſe depths; though I could wiſh theſe heats had been more regularly meaſured and aſcertained than what I can find they have yet been. So that it would ſeem the body of the Earth has a very great proper internal heat, independent on the Sun, and very much beyond what

[a] Mem. Hiſt. of the Air. Abr. III. p. 54.

[b] See Boyle Exp. on Cold. Abr. I. p. 641. 700, 701. 702. Boerh. Chem. I. p. 479. Woodw. Eſſ. Nat. Hiſt. of the Earth. p. 136.

he,

ESSAY VI. he, without the intervention of our atmosphere, could communicate to it; so great as within 90 feet of its surface to raise the Thermometer 93 divisions above *Fahrenheit*'s cold mixture, or 453 divisions above what M. *Amontons* reckoned the lowest degree of heat. This Heat of the Earth at its surface is something less, and beyond that its force decreases indeed very fast, so as to leave the air at a small height above it a good deal colder; and which we find on the very high hills to be excessively cold, and not to be much warmed by the additional heat of the sun's direct rays, if they be but little altered by the earth's surface and atmosphere.

30. It is not our business so much as to attempt the explaining the cause and consequences of this innate heat. That is the work of those who have fire and fancy enough to build worlds or theories of worlds. I will only beg leave to observe after the Lord *Verulam*[a], Mr. *Boyle*[b], and others, that the various temperatures of the air in differ-

[a] Seq. Chart. p. 102.

[b] Exp. on Cold Abr. I. p. 657.—660. 670. Mem. Hist. of the Air. Abr. III. p. 52.

ent

ent places of the earth do by no means correspond to what ſhould be the reſult of their poſition to the Sun. To omit variations that are ſmall and of leſs moment, I ſhall only take notice of the much greater cold in all the ſouthern hemiſphere than in the ſimilarly ſituated places of the northern one; and of the greater colds in the North *American* countries, than in thoſe of the ſame latitude on the *European* ſide of the globe. All which argues a copious fund of ſome other more potent cauſe of heat than the regular actions of the Sun; and that that cauſe, inherent in the earth itſelf, is ſtronger in ſome regions of it than in others; though every where conſiderable and of great force. ESSAY VI.

31. The ingenious Dr. *Halley* [a] has a very bold hypotheſis, which, beſide other purpoſes, he employs in accounting for this anomaly of theſe warm and cold quarters of the world. He imagines that once the Earth moved round an axis very different from the preſent; and ſo that "the extreme cold felt in ſome places, as in the "north-weſt of *America*, about *Hudſon's*

[a] Phil. Tranſ. Abr. VI, 2. p. 41.

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" *Bay*, may be occaſioned by thoſe parts " of the world having once been much " more northerly, or nearer the pole than " now they are ; whereby there are im- " menſe quantities of ice yet unthawed in " thoſe parts, which chill the air to that " degree that the Sun's warmth ſeems hard- " ly to be felt there ;" which after ſome thouſands of years have not yet, it ſeems, acquired a ſufficient heat. While by a parity of reaſon we may from the ſame principles infer, that the extraordinary ſoft temperature of ſome other places may be owing to their having originally been under or near the primitive equator, whereby they had acquired a heat which is not yet quite diſſipated.

But, beſide that in ſuch an hypotheſis thoſe places ſhould conſtantly be coming nearer and nearer to a regularity and uniformity with other countries alike in latitude and other ordinary circumſtances, the heat of bodies is ſo tranſient and fleeting, and the influence of the Sun reaches ſo little way into the body of the Earth, that I cannot conceive, even allowing the ſuppoſition of a changed axis, that the various degrees of the original primitive heats of the Earth, communicated

communicated to it by the Sun, could poſſibly have been ſo permanent and laſting, as to ſhew themſelves ſo effectually at this day. So that, as I ſaid before, ſuch a variety of heats muſt rather be owing to an internal cauſe operating more intenſely in ſome regions than in others; and every where much more ſtrongly than any influence the Sun can give them.

32. And if this be the caſe of the reſt of the planets as well as of our Earth, their heats, or the heats of bodies on their ſurfaces, will not ſolely nor even chiefly depend on the action of the Sun on them (as the philoſophical Aſtronomers [a] ſeem by their manner of ſpeaking to ſuppoſe) theſe proper innate heats having a greater ſhare in them than that external addition. Tho' this however may be neceſſary to ſupport and preſerve thoſe entire: ſeeing all warm bodies, that are not endowed with a vital principle of heat, are of their own accord

[a] See Newton Princip. p. 405. 406. 508. 509. Gregor. Elem. Aſtron. VI. Prop. 2. 3. 4. 5. 6. Whiſt. Præl. Math. p. 327. 328. New Theor. &c. p. 53. 78. Hugen. Coſmotheor II. p. 694. &c. Derham Phyſico-theol. p. 171—178.

liable to a conſtant waſte and decay of this quality.

23. But whatever be in this, from theſe conſiderations the heat of the Sun, and the heats of bodies approaching near him, will not be found ſo exorbitant as we have been accuſtomed to reckon them [a]. The proper or innate heats of the planets may be ſuch that the inner ones are in no hazard of being too much ſcorched, nor the far off ones of having too ſmall an allowance of the benign influence of the Sun's heat. And that, eſpecially by the help of peculiarly diſpoſed atmoſpheres concurring that way, there may be a great uniformity in this reſpect of the whole ſolar ſyſtem. Yea even the comets themſelves may, for any thing we know, be ſo conſtructed as to ſuffer no great inconvenience by their great excentricities, and very variable diſtances from the central fire.

34. But where am I going? I find my ſelf treading on ſlippery and enchanted ground. I fear I may be thought juſt now to have got too far into the bewitching and

[a] See Newton ibid. p. 508. Whiſton ibid.

airy

airy regions of fancy and conjecture, where I would not chooſe to dwell. However, at preſent having a delightful proſpect in view, I would fain be indulged in one queſtion before I quit this place. What if, abſtracting from the other ſolar influences of light, gravitation, &c. the great force and virtue of its additional heat on the bodies of planets (which is wiſely contrived to be very variable and ſhifting) is to produce frequent changes on the otherwiſe equable heats of their ſurfaces, for very great and noble purpoſes in the life and ſupport of their inhabitants? as at leaſt we know to be the ſtate of our globe, which by the viciſſitudes of night and day, and winter and ſummer, and ſpring and autumn, beſide other ends thereby accompliſhed, preſerves in action and life both vegetables and animals: all which would ſtagnate and die in a ſtate of heat always perfectly the ſame. For all natural organic bodies, from the loweſt vegetable to thoſe of the higheſt animal life, have, by the viciſſitudes of heat and cold they neceſſarily undergo, a conſtant oſcillation, a perpetual alternate contraction and expanſion of all their ſolid and fluid particles.

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35. So then the Sun, though it be not the ſole or chief fountain, is, as it were, the great regulator of motion, heat and life to the inhabitants of this ſyſtem; and on this account the benefits to us men of this great mover, this awakener and enlivener of nature, are highly to be prized. Which however were much miſtaken by the ancient heathen nations, and ſtill continue to be ſo amongſt many in the world; who having loſt the true religion and philoſophy of things, that were given to the firſt men, and ſo ſeeing things but by halves, and dazzled by the ſplendor of the ſun's light and power, and ſenſible influences [a], imagined that for their life and all the goods thereof they depended on that great luminary; and ſo worſhiped the creature inſtead of the Creator, the work inſtead of him that made it; the knowledge of whom they had utterly loſt. And this was never to be recovered without a new revelation, a new communication of himſelf from God to man; or a more accurate ſurvey and knowledge of the ſyſtem of nature than what mankind could of themſelves ſoon or eaſily arrive at;

[a] Wiſd. of Solom. xiii. 1—7.

by

by which the ſeveral connections, and ſub- ESSAY VI.
ordinate dependances of its parts one with another, and the great and univerſal dependance of the whole on a wiſe and omnipotent maker and ruler might be found out. An inquiry indeed of the greateſt concern to us men; and in which there have been very great ſteps made in theſe latter times, that do very much confirm and illuſtrate the revelation given to *Abraham* for the conſervation of the true religion, and continued to his poſterity; which was afterwards much farther extended by the laſt grand revelation concerning the great Creator, the Lord of heaven and earth, that made the Sun, Earth and Stars; and governs them all with infinite wiſdom and power.

IV. *Of the degrees of Heat in Animals.*

36. Thus much for the Celeſtial and Planetary Heats. But now let us come nearer home, and conſider the various degrees of heat in the living inhabitants of this our Earth, which we can ſee and feel, and examine by our ſenſes. A very fruitful enquiry, and of greater immediate ſatisfaction

ESSAY VI. and uſe to us, being what we are more particularly intereſted in.

The Heat of Animals is extremely various both according to the variety of their kinds, and the variety of the ſeaſons. Zoologiſts have juſtly enough divided them into *Hot* and *Cold*, that is to ſay with reſpect to our ſenſes. Thoſe that are any thing near our own temperature we call *Hot*; while all the others are reckoned *Cold*, whoſe heat is much below ours, and conſequently affects our feeling with the ſenſe of cold, though, according to what trials I have had opportunity of making, they are all by their *vis vitæ* kept ſomething warmer than the medium in which they live.

37. The gradations of life from the warmeſt animals down to perfectly inert matter are very ſlow, and by very ſmall and almoſt inſenſible degrees, ſeeing as it is not eaſy to determine the loweſt ſtate of vegetation; ſo too the limits between the higheſt vegetables and the loweſt animals are with difficulty to be diſtinguiſhed. Now all bodies partake of the heat of the *medium* ſurrounding them, as air, water, or any thing elſe. Nor can I find by the moſt careful

careful experiments purposely made, that vegetables, any more than the most inert and lifeless masses of matter, are endowed with any *vital heat* beyond the temperature of the ambient air, to be distinguished by the nicest Thermometers. As the air is a thin body, easily heated and cooled, so indeed when it is in a cooling state, as chiefly in the evenings and night season, it is colder than the plants in it. But on the other hand, for the same reason through most part of the day it appears, and really becomes warm sooner, and more sensibly than they can do. But when all are kept in an equable state, there is no difference of heat to be observed, the plants always corresponding exactly to the temperature of the ambient *medium*. "In vegetabilibus & plantis "nullus reperitur caloris gradus ad tactum, "neque in lachrymis ipsorum, neque in "medullis recenter apertis [a]."

38. Nay the animals of low life have but very little additional heat beyond that of the air or water. The insect tribe greatly disappoint our expectations, seeming to be the most tender and delicate of all animals,

[a] Bacon. Nov. Org. II, 12.

and

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and yet being thoſe that can unhurt bear the greateſt colds. They are preſerved in the coldeſt ſeaſons with little other ſhelter than the leaves and ragged barks of ſhrubs and trees; holes of the walls, or a very ſlight cover of earth, and ſome expoſe themſelves quite naked and open. [a] Even in the bitter winters of $170\frac{8}{9}$ and $172\frac{3}{9}$ the inſect eggs, nymphas, and aurelias outlived the colds that were intolerable to the livelier animals. And we know how vaſtly low the fluid then ſubſided in the Thermometers. Mr. de *Reaumur* [b] found ſome very young ſlender caterpillars that were able to bear a cold under *gr.* 4. And what is ſtill more, the *French* Mathematicians in their *Lapland* journey in the autumn were peſtered with innumerable ſwarms of flies of various kinds [c], whoſe eggs and aurelias muſt have wintered under ſtill greater colds than this. And I find that caterpillars have but a ſmall degree of heat, about a diviſion or two above the air they live in.

[a] Boerh. Chem. I. p. 287. 415.
[b] Mem. Ac. Sc. 1734. p. 257.
[c] Maupert. Fig. de la Terre p. 12. See too Boyle Exp. of Cold Abr. I. p. 661.

39. The whole insect tribe is commonly brought under the class of Cold Animals [a]. On which account I cannot but take particular notice of a very singular exception in the heat of Bees, a very remarkable branch of that *genus* of living creatures. As these, according to the curious observations of Naturalists, have something very peculiar in their œconomy, fabric and generation; so I have observed that they have a very singular constitution in the heat of their bodies. This I have experienced frequently; and I find that the heat of a swarm of bees raises a Thermometer buried amongst them above *gr.* 97; a degree of heat nothing inferior to our own.

40. The other animals of low life, agreeable to what I observed of the ordinary insects, have but very little additional heat above that of their supporting medium. I could scarcely distinguish any in Muscles and Oisters. It was very little in the Branchial fishes. In Flounders, Whitings,

[a] Vid. Bacon. Nov. Org. II, §. 11. p. 167. §. 12. p. 186. §. 13. p. 192. Nat. Hist. 73. Lister de Bucc. p. 245.

Codfish,

ESSAY VI. Codfiſh, and Haddocks the heat was found ſcarce a degree more than the ſalt water they were ſwiming in, even when that was ſo low as *gr.* 41. Nor are the red fiſhes much warmer than they. Some Trouts, whoſe heat I examined were but at *gr.* 62, when the river water they had been ſwiming in was at *gr.* 61 *. Fiſh can live in water any thing warmer than freezing, that is any thing above *gr.* 32.

41. The reſult of ſeveral trials made Snails about 2 degrees warmer than the air. Frogs and Land Tortoiſes ſeemed to have the principle of heat ſomething ſtronger, *viz.* about 5 degrees higher than the air they breathed in. Which I ſuppoſe to be the caſe of the ordinary breathing animals, who indeed have lungs (but theſe lungs of a wide veſicular form) and have their blood not a great deal warmer than the Branchial fiſhes. Such I take to be the Sea Tortoiſes, Toads, Vipers, and all the ſerpent kind, who all have their lungs of the ſame fabric,

* And lately at Paris I found the heat of a Carp ſcarcely to exceed *gr.* 54, the heat of the water wherein I examined it. The heat of an Eel came out in the ſame way.

and

and the ſame cold conſtitution of blood. But moſt of this ſort of animals are not able to bear very great colds; they in the ſevere ſeaſons retiring into lurking places, where they are tolerably well ſheltered; often perhaps at about the middle temperature of *gr.* 48 or ſo. Their *vis vitæ* is indeed in thoſe ſeaſons very low [a], and their waſte of ſubſtance exceeding ſmall [b]. And I ſuppoſe the ſame may be ſaid of the Swallows, and other ſleeping Birds and Beaſts, who, though naturally warm animals, much warmer than thoſe already mentioned, are however in their inert ſtate probably much colder than in their active and lively ſeaſons.

42. For the heat of hot animals is not uniformly the ſame in all animals, and at all times. That admits of a very great latitude: it varies according to their various kinds and the circumſtances of each. The ſurface of their bodies are, like other things, much affected by the heat or cold of the

[a] See Harv. de Mot. Cord. &c. IV. p. 28. XVII. p. 65. Liſter de Cochl. p. 164. de Bucc. p. 246. 251.

[b] See Phil. Tranſ. Abr. II. p. 825. Liſter de Cochl. p. 163. 165.

ESSAY VI. ambient medium, and consequently wrought upon by all the varieties of seasons and climates, if not sufficiently sheltered from their influences. When that is their external and internal heat is nearly the same; but still differing something in different animals.

43. Dr. *Boerhaave* [a] indeed speaks of the heat of hot animals as in a natural state pretty uniform, or the same in all, reckoning it commonly to be such as to raise the mercury in the Thermometer to *gr.* 92, or at most 94. And so too Dr. *Pitcairn*'s [b] heat of the human skin at his *gr.* 17 falls near our *gr.* 92. Mr. *Amontons* [c], by several trials found the heat communicated by the human body to his Thermometer to be at *dig.* $58\frac{2}{12}$, $58\frac{5}{12}$, $58\frac{6}{12}$, $58\frac{7}{12}$, $58\frac{9}{12}$. These by calculation I find to fall about *Fahrenheit*'s *gr.* 91, 92 and 93. Sir *Isaac Newton*'s [d] *gr.* 12, which he makes equivalent to the external heat of the human body, and to the heat of a bird hatching eggs, comes to *gr.* $95\frac{1}{2}$ in ours. *Fahren-*

[a] Chem. I. p. 192. 207. 213. 414. 415. 526.
[b] El. Med. II, 1. §. 26.
[c] Mem. Ac. Sc. 1703. p. 235. 243. Phil. Transf. Abr. IV, 2. p. 1. 3.

heit

heit [a] himſelf places his heat of the human body and blood at *gr.* 96. And at this mark Dr. *Muſſchenbroek* [b] ſays the Thermometer ſtands, when it is immerged in the blood flowing from an animal; though in another [c] place he ſpeaks of *gr.* 92 or 94, as a pretty high degree of heat for our blood.

44. I have very carefully made numberleſs obſervations on this ſubject of the heat of animals: and from them I muſt be allowed to ſay that I find all theſe reckonings much too general, and in the main conſiderably too low. I ſuſpect that, at leaſt in many of them, there was not ſufficient time allowed to warm thoroughly the bulbs of their Thermometers; or perhaps at the time of trial the folks hands had not the natural ſheltered heat. The human kind is amongſt the loweſt of hot animals [d]: and yet I by the heat of my ſkin every way well ſheltered, at a medium in an infinite number of trials, raiſe the Mercury in the Thermometer to about *gr.* 97 or 98. In

[a] Phil. Tranſ. Abr. VI, 2. p. 18. 52.
[b] Eph. Ultraj. 1728. p. 679. [c] Eſſ. de Phyſ. p. 502. [d] Cæſalp. Qu. Perip. V, 6. p. 132.

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ſome it goes a little higher, in others it keeps ſomething lower. Urine new made, and that into a veſſel of the ſame temperature with itſelf, is ſcarcely a degree hotter than the ſkin, as I have found by many repeated obſervations. And that heat of the urine we may reckon nearly equal to the heat of the neighbouring *viſcera*. Dr. *Hales* [a] found the heat of his ſkin to be 54, and that of urine new made 58 degrees of his Thermometer, which coincide with our *gr.* 99 and 103, if the calcul that was made of the correſpondence of his Thermometer with *Fahrenheit*'s had been perfectly exact.

45. In the mean time, as I juſt now ſaid, the human kind is among the loweſt of hot animals. Ordinary quadrupeds, as Dogs, Cats, Sheep, Oxen, Swine. *&c.* by the heat of their ſkin raiſe the Thermometer 4 or 5 diviſions higher than we, as to *gr.* 100, 101, 102, and ſome to 103 or a little more.

46. And the breathing or Cetaceous fiſhes are as hot as they, as Dr. *Boerhaave* [b]

[a] Veg. Stat. p. 59. [b] Chem. I, p. 415.

very

very juſtly reckoned; though he aſcribes too ſmall a heat to them, and to all other reſpiring animals, when he confined it within the narrow bounds of 92 or 93 degrees. Thoſe who have had occaſion to travel into the *Eaſt-Indies* [a] tell us, that the blood of the Manati Fiſh, or Sea Cow, was ſenſibly warm to the touch. And Mr. *Richer* [b], a curious enough obſerver of natural things, found the blood of the Porpus as warm as the blood of land animals. I myſelf upon trial found the heat of the ſkin of that amphibious animal the Sea Calf to be near *gr.* 102. In the cavity of the *abdomen* it was about a diviſion higher. In all this, as in many other reſpects, agreeing with our ordinary land quadrupeds; which in the ſtructure and form of their *viſcera* the breathing fiſhes do very much reſemble.

47. The Lord Chancellor *Bacon* [c] gives it as a current opinion that the bird kind are very warm. They are indeed the

[a] See Ent Apolog. &c. p. 207. Le Comte Mem. de la Chine II. p. 343.

[b] See Du Ham. Hiſt. Ac. Sc. p. m. 157. Mem. Ac. Sc. 1666—1668. VII. p. 325.

[c] Nov. Org. II, 13. p. 193.

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warmeſt of all animals, warmer ſtill than quadrupeds by 3 or 4 degrees, as I have found by experiments on Ducks, Geeſe, Hens, Pigeons, Partridges, Swallows, *&c.* The bulb end of the Thermometer being lodged in their groin, the Mercury was raiſed to *gr.* 103, 104, 105, 106, 107; and in a Hen hatching eggs I once found (for it is not always ſo high) the heat at *gr.* 108.

48. It was I preſume without ſufficient ground that the juſt now mentioned noble Lord [a] reckoned the external fleſh of animals, when in action, to be hotter than their blood, *&c.* Generally in my experiments both on Birds and Quadrupeds the *viſcera* were found near a degree hotter than the ſkin; though ſometimes I could perceive but little or no odds. And a Thermometer thruſt into a fiſtulous ulcer running in amongſt the muſcles of the thigh in a man ſhewed a heat very little greater than that of the ſheltered ſkin.

49. As the circulation is ſo very quick and free, the heat of the blood in the

[a] Ibid.

arteries

arteries and veins is pretty much the ſame, and but a ſmall matter, it may be a degree or ſo, above the common heat of the bowels, or near 2 degrees warmer than the ſkin; a much ſmaller difference than what Sir *Iſaac Newton* [a] and Dr. *Hales* [b] aſſign; according to whoſe reckonings that would be no leſs than 10 or 11 degrees.

V. *Of the preternatural Heats of Animals.*

50. Theſe then are the Heats of Animals as in my experiments they generally appeared to me. But they are not to be held as univerſal. Beſide the varieties in different individuals, the heat even in the ſame animal does not keep always the ſame. For ordinary indeed and in health the variations are not great; but by diſeaſes and extraordinary accidents it may be much altered, and brought both above and below the natural ſtandard. I cannot ſay that I have yet had opportunities of making obſervations enough to lay down any thing ſufficient or ſatisfactory concerning the Heat of Animals in preternatural or morbid ſtates.

[a] Phil. Tranſ. Abr. IV, 2. p. 1. 2.
[b] Veg. Stat. p. 58. Hæmaſt. p. 98.

ESSAY VI. However I think I may venture to say that it is not so vastly great in fevers as some are apt to conjecture.

51. The medical writers all take notice of the constant and burning heats in ardent fevers. And we are told [a] of the Emperor *Constantius* and of some others, that they were of such a hot dry temperament, as, when heated by a fever, in some measure to burn the hands of those that touched them. But this burning heat no body then knew how to measure, or to preserve to us any distinct intelligible notion of it. The determining and affixing the due bounds to such things being reserved to this present age. The ingenious Dr. *Hales* [b] supposes the heat of the blood in high fevers to be about *gr.* 85 in his Thermometer, which comes to *gr.* 136½ in ours; a degree of heat, which I believe no animal ever arrives at, nay which I reckon no living creature is able to bear. Dr. *Boerhaave* [c] furnisheth us with some curious observations of animals very soon destroyed in air of *gr.* 146, who all died in less time than

[a] See Bacon. Nov. Org. II, 13. p. 192.
[b] Veg. Stat. p. 60. [c] Chem. I. p. 275.

what

what would have been neceſſary to bring their bodies up to the heat of *gr.* 136. A Thermometer put into one of their mouths a little after its death ſtood at *gr.* 110.

52. Nor on the other hand would I ſuppoſe the fever heat ſo low, or that low heat ſo dangerous, as the great Dr. *Boerhaave* [a] ſeems to do. He is afraid of its coagulating the *ſerum* of the blood, reckoning that terrible miſchievous work might be effected by a degree of heat not much above *gr.* 100. Whence Dr. *Hales* [b], and Dr. *Arbuthnot* [c], led thereto by Dr. *Boerhaave*'s authority, affirm that the natural heat of the blood of a human creature approaches very near the degree of coagulation. But I have ſeen fevers, and theſe not exceſſively violent neither, wherein I was aſſured, by obſerving the heat of the ſkin, that the blood was 5 or 6 degrees above *gr.* 100, without apprehending any ſuch danger, or experiencing any ſuch fatal ef-

[a] Aph. 96. 689. Chem. I. p. 343. II. p. 352. 353. 378. 213. 357. 358.
[b] Hæmaſt. p. 104. 105.
[c] Eſſ. on Air. p. 114. 211.

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fects*. Such a heat, if neglected or wrong managed, may indeed, as *Hippocrates*[a] very juſtly obſerves, diſſipate the more thin and watery parts, and ſo gradually thickening the whole maſs of blood, have bad enough effects that way; if it do not bring on a putredinous thinneſs. But directly to coagulate the *ſerum* of blood, or the white of an egg, by ſeveral trials I found a heat requiſite beyond any thing ever we can experience in a living animal. They continue thin and liquid till the Thermometer points at *gr.* 156 or ſo. Which is an arithmetical mean betwixt the ordinary heat of human blood at *gr.* 99 or 100, and that of boiling water at *gr.* 212; exceeding the one juſt as much as it falls ſhort of the other.

52. But no animal I ſay can bear a heat near this. Beſide the bad effects it would

* In the Ague I had lately, during the height of the paroxyſm, the heat of my ſkin was *gr.* 106; and ſo that of my blood *gr.* 107 or 108. And farther, what is very remarkable, in the beginning of the fit when I was all ſhivering, and under the greateſt ſenſe of cold, my ſkin was however 2 or 3 degrees warmer than in a healthy and natural ſtate.

[a] IV De Morb. XXIII, 23, &c.

have

have upon the fluids, I know our nerves are not able to endure ſuch a ſcorching heat. If that be but a few degrees hotter than our blood it comes to be intolerable. Sir *Iſaac Newton* [a] and Mr. *Amontons* [b] felt water too hot for their hands ſtirring in it eaſily to bear at *gr.* 108. I ſuſpect indeed the full heat of the water had not been thoroughly communicated to their too bulky Thermometers. I find it becomes ſcalding hot to my hands and feet at *gr.* 112 or 114. And ſo I reckon will moſt people find, who have not their organs too callous. We ſhould not however judge of the delicacy of the body by the ſenſation of the hands, which in many folks by labour and uſe are rendered preternaturally inſenſible. Mr. *Amontons*'s valet could bear water of the heat of *gr.* 122. And I have ſeen folks who could handle things freely I could not well touch. I doubt not but the hotter animals can likewiſe bear a greater heat than we. And on the other ſide fiſhes and cold animals may be ſcalded to death with a heat leſs than that of our blood. A Perch, one of the moſt lively of the

[a] Phil. Tranſ. Abr. IV, 2. p. 2.
[b] Mem. Ac. Sc. 1703. p. 236. 244.

Branchial fiſhes, died in 3 minutes in water heated but to *gr.* 96 [a].

53. At firſt men often gave names to things from certain reſemblances without pretending thereby to underſtand or exhibit their natures. And in this view Phyſicians may continue to talk of the τὸ πυρ, the *Febris ardens*, and *Inflammations*, and freely uſe theſe and other fiery names, if they mean no more by them (as it is likely they did not in the original uſe of them) than a figurative way of expreſſing extraordinary heats of the body, or the heat of the blood carried conſiderably beyond its natural ſtate. But from undeniable experiments we ſee they muſt be much miſtaken, who not confining themſelves to the figurative uſe of theſe names, and led aſtray by vain and ill grounded theories, talk of real ſcorchings of the body, and actual burnings of the heart and other *viſcera*, of ebullitions and effervеſcencies of the blood, of its being kindled and ready to burſt into flame [b], and of other ſuch fiery deſcriptions of heats, which no animal, while in life, can be

[a] Muſſchenbr. Tent. Exp. Ac. Cim. Add. p. 122.
[b] Willis Pharm. Rat. II. p. 22.

brought

brought into. So that these are ways of speaking, which, to prevent mistakes, should have no place out of Poetry; where alone such bold figures, and these expressed in such a strong manner, without any restriction, are to be allowed. Thus some people by their profession may be permitted

> Jecur *to burn and* Cor *to pierce,*
> *As either best supplies their verse* [a].

But for others, who from the nature and great consequence of the subject they deal in should be more strictly tied to truth, gravely to talk of the Liver burning up the Bile, and speaking of the Heart as they would of a piece of red hot iron burning the hands of those that touch it [b], or boiling up into froth the blood that falls into it [c]; and others to give out the Stomach as a kettle boiling our food by its great

[a] Prior. Alma. p. 87.

[b] Abu Jaafar Ebn Tophail Philos. Autodid. p. 64. Ali Rodoan apud Gom. Pereir. Antonian. Marg. p. 326. 770. Columb. De Re Anat. XIV. p. m. 477. 481. Diemerbr. Anat. II, 6.

[c] Des Cartes de Meth. 5. p. 29. De Hom. p. 8. De Form. Fœt. §. 18. 72. De Pass. I, 8. 9. Epist. I, 52.

heat;

ESSAY VI. heat [a]; such assertions, I say, as these are unwarrantable impositions on the senses of mankind, and should be dropt by all sober thinking men.

54. We see then that nature seldom carries the body or blood of animals to a degree of heat very much beyond its ordinary healthy temperature. Nor indeed are we able to bear any very great excess of that kind, either in the body itself, or in the medium without us. We can however on the other hand endure greater excesses of cold, at least externally affecting us; there being many remarkable instances of the surface and extremities undergoing very great colds without being absolutely destroyed. We have all, I suppose, some time or other even here experienced very sharp nipping colds. These however are nothing compared to the frightful accounts we have had of the great prevalency of cold on the bodies of men and other animals in the more northern countries. Often are they quite frozen to death; but at other times, though the cold has gone a great length, they are

[a] Hipp. apud Cels. Med. Præf. p. 6. Stukely of the Spleen. p. 35.

happily

happily recovered. We have been told[a] of animals found ſtiff cold in their lurking places, or buried in lumps of ice, that by the *Stimulus* of pain or a warmer air have been again brought to their life and ſenſes. Partial freezings of the noſe, hands, feet, &c. of the human body are frequent. But what is much more there are inſtances[b] of men being ſo frozen by the lump, that when plunged into cold water they contracted a cover of ice over their whole body, which therefore in all its exterior parts muſt have had a cold conſiderably under *gr.* 32. If it came ſo low as *gr.* 25 the blood muſt have been frozen in ſome of its veſſels. However even in this terrible threatning ſtate, when the whole body ſeemed to run ſuch a riſque of congelation and the ſleep of death, by good management, well underſtood in theſe intemperate countries, people have been recovered to their life again. In ſuch extreme caſes one would think that the internal heat muſt too have been conſiderably impaired: but how low that may be carried without danger or immediate death we cannot yet de-

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[a] Boyle Exp. on Cold Abr. I. p. 671. 673. Queſnay Oecon. Anim. p. 25.

[b] Fabr. Hild. de Gangr. &c. XIII. p. 792.

termine.

ESSAY VI. termine. In the mean time the measuring the heat of the Birds and Beasts that pass the winter in a state of sleep and insensibility might give us some light into this matter.

Thus much in general of the Heat of Animals: that subject having been more minutely handled in another treatise *De calore animalium.*

What follows is more in the nature of a plan of what is proposed or should be done on the respective heads, than any thing fully executed on them.

Heads to be added.

VI. Of the Heats of Waters, Oils and Salts, according to their fluidity and consistency.

VII. Of the melting and shining Heats of Metals and Minerals.

VIII. Of the boiling Heats of liquid and melted Bodies.

IX. Of the Heats of Flame and Fire.

VI. *Of the Heats of Waters, Oils and Salts, according to their fluidity and conſiſtency.*

The conſiſtency or fluidity of moſt bodies are no eſſential or permanent properties in them; but are rather a ſort of circumſtances or accidents manifeſtly depending on the various degrees of heat applied to them. Some of the hardeſt bodies may be reduced to a fluor by fire. Stones, Metals, Salts, *&c.* ſome by leſs, ſome by greater degrees of heat may be melted down into fluids; which only continue ſo, as long as the requiſite heat laſts. On the other hand moſt of theſe bodies, which to us commonly appear in a fluid ſtate, by cold, or the diminution of heat, may be brought to a conſiſtent form. And if there be ſome fluids which have never been ſeen to freeze, this may, with a great ſhew of reaſon, be aſcribed to the difficulty or perhaps impoſſibility of getting altogether rid of heat. And for the greater illuſtration of the doctrine of Heat; and to get a farther view into the natural hiſtory and philoſophy of Bodies, we will here endeavour to ſettle the limits of Firmneſs and Fluidity in a

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great many of them, as far as our own, or other peoples obſervations can carry us: for the greater uniformity reducing them all to *Fahrenheit*'s ſcale; which we will ſuppoſe protracted even much beyond the heats his Thermometer could bear.

It is a bold but a very juſt expreſſion of Sir *Iſaac Newton*[a], when he calls "*Water* "a fluid taſteleſs ſalt; which," adds he, "nature changes by heat into vapour, and "by cold into ice, which is a hard fuſible "brittle ſtone, and this ſtone returns into "water by heat." Agreeable to which view of things Dr. *Boerhaave*[b] calls Water a kind of glaſs that melts at a heat any thing greater than *gr.* 32; the boundary between Water and Ice.

All our ordinary Liquors are but Water with an additional mixture of Oils, Salts and Earth; and have all or moſt of them been obſerved to freeze, ſome at a greater and ſome at a leſs degree of cold under the freezing of common elementary Water.

The animal Liquors generally loſe their fluidity eaſily enough. Dr. *Boerhaave*[c] ſpeaks as if *Blood* would freeze as ſoon as

[a] Opt. p. 349. [b] Chem. I. p. 399. 614.
[c] Chem. II. p. 377.

Water, *viz.* at *gr.* 32. But on trial it is found to reſiſt the cold ſomething more. The Blood of a Lamb was not frozen at *gr.* 29; but it was turned into Ice at *gr.* 25 [a]. And ſome of the cold animals preſerve the fluidity of their liquors ſtill more obſtinately. Some Inſects indeed were killed and their bodies hardened at about *gr.* 20 [b]. But there are others that reſiſted the cold below *gr.* 4; preſerving the life and ſoftneſs of their bodies, and the fluidity of their juices [c].

Milk is not ill to harden, freezing I think at about *gr.* 30.

Ordinary *Urine* freezes at *gr.* 28, though if it be ſtrongly impregnated with Salts and Oils it may continue fluid in a cold ſomewhat greater.

Fermented Liquors do not freeze ſo eaſily as ſimple Water; and the ſtronger they are they can bear the greater cold; and when they are frozen, it is the weakeſt parts that ſuffer firſt, the ſtronger and more ſpirituous often continuing fluid. Small Beer and ſmall Wines eaſily turn into Ice; and the great colds in *Moſcovy*, *Greenland*,

[a] Reamur in Mem. Ac. Sc. 1734. p. 260.
[b] Ibid. p. 259. [c] Ibid. p. 257. 258.

Hudſon's

ESSAY VI. *Hudſon's Bay*, &c. froze the ſtrongeſt Wines, as ſtrong Claret, Malaga, Alicant, *&c* [a].

Such colds were certainly very great; but thoſe who had occaſion to obſerve them, had not the means of taking any exact eſtimate or determined meaſure of them; which, if an opportunity were offering, we can do now with greater certainty *.

Not only the ſtrongeſt Wines may be frozen. Brandy itſelf has been converted into ice [b]; the ſtronger part, if there be bulk enough of the liquor, uſually retiring to the center (as in the freezing of ſtrong Wine) and there conſtituting a ſtronger Spirit of Wine ſeparate from the reſt. And ſuch muſt undoubtedly have been a very great cold. Brandy eluded Dr. *Muſſchenbroek*'s [c] attempt to freeze it with the cold of ſnow and beaten ice. A mixture of tolerably well rectified Spirit of Wine and Water in equal parts, which I reckon would

[a] See Boyle Exp. on Cold Abr. I. p. 594. 607. 609. 610. Scept, Chym. Abr. III. p. 281. Phil. Tranſ. Abr. II. p. 152. Merret Exp. of Cold. p. 47. 48.

* Laſt winter I found good Burgundy, ſtrong Claret, and Madera to freeze at about *gr.* 20.

[b] Boyle Exp. of Cold Abr. I. p. 594.

[c] Tent. Exp. Ac. Cim. Add. p. 176.

make

make a liquor about the ſtrength of common Brandy, was not frozen but with the cold of—*gr.* 7. A weaker mixture of 1 part Spirit to 3 of Water froze at *gr.* 7. But on the other ſide, a ſtrong mixture, where the Spirit was double the Water, did not freeze till the cold came down to —*gr.* 11 [a].

But Mr. *de Reaumur*'s rectified Spirit of Wine itſelf underwent in the winter at *Torneao* a cold greater than any thing he was able to make in *France*. There too it was frozen[b], though at what degree we cannot tell. Only we are ſure that the cold able to do it was no greater than—*gr.* 34; perhaps a good deal leſs. If people were appriſed and on their guard, this might be accurately enough determined in ſuch cold countries; where I ſuppoſe the moſt perfect Alcohol might be frozen; and perhaps even the lately invented ætherial Spirit of Wine itſelf.

Vinegar is the produce of a ſecond proceſs of fermentation, whereby all the Oil and Spirits of the Wine are converted into a lean acid liquor, that reſiſts cold pretty much, and (like Wine and ardent Spirits)

[a] Reamur in Mem. Ac. Sc. 1734. p. 255.
[b] Maupert. Fig. de la Terre p. 38.

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the ſtronger it is, the more. Common Vinegar is indeed not difficult to freeze, that may ordinarily happen at about *gr.* 28. But when freed of a great deal of its phlegm by diſtillation, under the name of Spirit of Vinegar, it reſiſts a much greater cold. However it was frozen when expoſed to an intenſe cold, as Mr. *Boyle* [a] tells us; as alſo when ſurrounded by an artificial mixture of Snow and Spirit of Nitre. But Dr. *Muſſchenbroek* [b], who tried the experiment after Mr. *Boyle* [c], neglected to obſerve, or at leaſt to tell us, the cold of that Vinegar Ice. In this freezing there was a part of it continued fluid; the ſtrongeſt and moſt concentrated Vinegar that can well be imagined. And yet this too, by a new application of the cold mixture, was wholly turned into ice [d]; whereby its ſtrength and acidity was conſiderably impaired.

But the ſtrong *Mineral Acid Spirits* preſerve their fluidity much better; excepting however Oil of Vitriol, which begins congelation (or coagulation rather) near as ſoon as

[a] Exp. on Cold Abr. I. p. 593.
[b] Tent. Exp. Ac. Cim. Add. p. 175.
[c] Exp. on Cold Abr. I. p. 590.
[d] Muſſchenb. Ibid. p. 176.

fair

fair Water [a]. In the trials which Mr. *Boyle* [b] and Dr. *Merret* [c] made in the very cold weather they found nothing of freezing in Aqua Fortis, Spirit of Nitre, Spirit of Salt, Vitriol, *&c.* Nay the ordinary cooling mixtures does not affect them. But *Fahrenheit* by reiterating such cold affusions produced a very intense cold at—*gr.* 40, whereby Spirit of Nitre itself congealed and shot into crystals [d].

The *Alcaline Spirits* do not seem to be endowed with so great a power of resisting cold. Spirit of Urine and Spirit of Human Blood were frozen in cold weather in England [e]. And a cooling mixture of Snow and Spirit of Nitre congealed Spirit of Sal Ammoniac made with Lime [f]. This mixture was able to freeze Spirit of Vinegar, and weak Spirit of Salt, and to turn other saline liquors into figured ice. But it

[a] Merret Acc. of Freez. p. 8. Confer & Boyle Abr. I. p. 396. 559. III. p. 482. But it seems this its disposition to freeze or coagulate goes off by time. See Musschenbr. Ess. Phys. §. 920.

[b] Boyle Exp. of Cold Abr. I. p. 596.

[c] Merret Acc. of Freez. p. 17.

[d] See Boerh. Chem. I. p. 164. 165.

[e] Boyle Exp. on Cold Abr. I. p. 593. 597. Exp. on Blood. III. p. 482.

[f] Ibid. p. 590.

ESSAY VI. had no discernible influence on Spirit of Nitre.

Water impregnated with a moderate quantity of any of the ordinary Salts freezes in cold weather; as with Sugar, Alum, Vitriol, Nitre, Sea Salt, Verdigrease, Arsenic, Sal Ammoniac, Kelp, Lixiviate Salt, &c [a]. But a solution of Sal Gem did not freeze with the rest [b]. And Oil of Tartar *per deliquium* was brought to congeal only by a mixture of Snow and Salt [c]. Sea Water freezes, whatever has been inadvertently said to the contrary. The northern voyages are full of this [d]. The *Zuyder Sea* in *Holland* is often frozen up. And the *Baltick* is a strong instance offering itself every year of the Sea Water being converted into ice. Nay it freezed at *London* with Mr. *Boyle* [e]. And I have found small parcels of saline bitter ice in some places of our sea rocks, where the water had been tossed up, and allowed to stagnate. The freezing point of Sea Water is at *gr.*

[a] Boyle Exp. on Cold Abr. I. p. 590. 593. 596. Merret Ibid. p. 4. 5. 7.
[b] Merret Ibid. p. 7. 8. 47.
[c] Boyle Ibid. p. 593. 596.
[d] See Musschenbr. Eff. Phys. §. 925.
[e] Exp. of Cold. p. m. 147.

But

But Water, when fully ſaturated with thoſe Salts, doth not eaſily freeze [a]. That ſuch ſolutions reſiſted the colds in *England* will not be wondered at. But we are told that a ſtrong Brine of Bay Salt cannot be frozen even in the northern countries [b]. And Syrups, which are but ſtrong ſolutions of Sugar and Water boiled up together, are not congealed with any ordinary cold [c].

Of Oils.

Oils too may be frozen, or at leaſt coagulated by cold. And ſome of them, as the Reſins, common Sulphur, Sperma Ceti, Tallow, Butter, *&c.* exiſt ordinarily in a conſiſtent form, though in their nature they are as truly Oils as thoſe that moſt obſtinately retain their fluid ſtate. But as Oils are gradually thinned by heat or thickened by cold, the limits between their conſiſtency and fluidity are not ſo exactly determinable in them as in watery ſubſtances.

Very many Oils preſerve their fluidity in great colds [d]. We have not heard of the

[a] Boyle Exp. on Cold Abr. I. p. 597. Merret Ib. p. 6.
[b] Phil. Tranſ. Abr. II. p. 152.
[c] Merret Ibid. p. 52. 53.
[d] See Boyle Exp. on Cold Abr. I. p. 596. 597. Orig. of Heat, &c. Abr. I. p. 559.

ESSAY VI. ordinary distilled Oils being frozen; except that once Mr. *Boyle* [a] found that unrectified Oil of Turpentine had its upper part turned to ice. And Oil of Anise for ordinary appears in a sort of Butter state till it be warmed to *gr.*

Even many of the expressed Oils stand out the cold very well; such as Oils of Linseed, Hempseed, Nuts, Sweet Almonds, *&c* [b]. But common Oil of Olives stiffens and grows opaque very soon, as at about *gr.* 43. But different Oils, and different parts of the same Oil freeze at different degrees of heat. So that we see some part of this Oil sometimes continue fluid in pretty strong frosts.

Wax is a vegetable Oil collected from flowers by the Bees. This swims on water, and does not lose its firmness and opaqueness till that be heated to *gr.* 142.

All the Resins may be looked on too as vegetable Oils, and they melt with a heat below that of warm water. Common Rosin comes to a sort of fluid by the heat of about *gr.*

Many of the mineral Oils appear for ordinary fluid, as Petroleum, Naphtha, *&c.*

[a] Ibid. p. 597.

[b] Boyle Orig. of Heat, &c. Abr. I. p. 559. Exp. on Cold Abr. I. p. 598.

nor

nor are we yet informed at what cold they become firm. Others again, as Asphaltos, Succinum, *&c.* we find always in a firm dry form; but which may be melted by heat. And Sulphur too is such an Oil. And Flowers of Brimstone, that is to say pure Sulphur melts into a fluid with the heat of *gr.*

Train Oil does not easily freeze [a]. And I suppose it was from this that *Olaus Magnus* [b] tells us, that it is usual in the northern regions to fill up the frozen ditches of fortified places with Train Oil in the winter, to preserve the lower water fluid. But Mr. *Boyle* [c] and Dr. *Merret* [d] found it frozen even by the cold weather of *England.*

But the other ordinary animal Oils rather take a considerable heat to keep them fluid. Butter is such an Oil. And that in the month of *May* took a heat between *gr.* 80 and 90 to oil it: but being so heated it keeps something thin till it fall to about *gr.* 74.

Hogs Lard.

Tallow.

[a] Boyle Exp. on Cold Abr. I. p. 596. 598.
[b] Vid. Ibid. p. 596. [c] Ibid. p. 596. [d] Merr. Ibid. p. 47.

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Sperma Ceti is the firmer part of the Oil of the *Macrocephalus* or *Dentatus* Whale; and does not melt with a heat under *gr.*

Of Salts.

We lately propoſed Common Water as a taſteleſs Salt diſſolvable by a ſmall degree of heat. What if on the other hand we ſhould reckon the ordinary *Salts* as different Waters brought to a liquid ſtate by a greater degree of fire, ſome ſooner ſome later.

Alum melts into a fluid at *gr.*
Sea Salt.
Borax.
Nitre.
Sal Ammoniac.
Strong Alcali Salt.
Vitriol.

VII. *Of the melting and ſhining heats of Metals and Minerals.*

And now are we come to conſider thoſe, which of all terreſtrial bodies, except elementary Earth itſelf, are the moſt conſiſtent

ent and firm, and moſt ſuſceptible of the greateſt heats; I mean *Metals* and *Mineral* ſubſtances. They are naturally in a conſiſtent form: but ſome of them flow at a moderate enough fire; while others require ſo intenſe a heat to diſſolve them, that we find it difficult how to bring it to a calcul.

☿

Quickſilver is always reckoned in the claſs of Metals. But it is ſo far from the common conſiſtent form and appearance of other Metals, that it may juſtly be looked on as the trueſt viſible and tangible fluid in the world. By ſome ſlight additions it may indeed be robbed of that property. But when left to itſelf pure and unmixed, it always preſerves its fluidity in the very greateſt colds natural or artificial that have ever been obſerved [a].

♃ ♄ ♂

Of all the ordinary ſimple Metals or

[a] See Boyle Exp. on Cold Abr. I. p. 597. Boerh. Chem. I. p. 36. 165. De Maupert. Fig. de la Terre p. 58.

Metallic

ESSAY VI. Metallic Subſtances *Tin* loſes its conſiſtency, and flows the eaſieſt, or with the loweſt heat. By Sir *Iſaac Newton*'s obſervation [a], reduced to the numbers of our Thermometer, it melts at *gr.* $(\frac{71 \times 180}{34} + 32 =) 408$. Dr. *Muſſchenbroek*'s experiments [b] carried it but a little higher, *viz.* to *gr.* $(\frac{109 \times 180}{53} + 32 =) 422$. And there may be greater differences from accidental mixtures. Sir *Iſaac*'s experiments of moſt of the Heats below this of Tin are, I believe, pretty near the truth. The Heats beyond this being deduced in a more precarious way we cannot be ſo ſure of.

Lead is the Metal next to Tin that fluxes eaſieſt. But here I do not find different folks obſervations agreeing ſo well as in the other. In Sir *Iſaac*'s way of finding out the heat of Lead beginning to melt, that would fall on our *gr.* 540 [c]. But according to *Muſſchenbroek*'s experiment [d] reduced to our numbers, the Mercury by ſuch a heat ſhould riſe to *gr.* 769; were it ſuſceptible of ſuch a great expanſion in a

[a] Phil. Tranſ. Abr. IV, 2. p. 2. 4.
[b] Tent. Exp. Ac. Cim. Add. H. p. 21.
[c] Ibid. p. 2. [d] Ibid.

regular

regular manner. And Mr. *Amontons*[a] found Gun-powder to be kindled by the ſame heat that melted Lead.

Some bodies, by being combined into one maſs, become more firm than either were in a ſeparate ſtate. And on the other hand others, when put together, make a compound more diſſolvable than its ingredients; much contrary to our expectations. So little ſhould we pretend *a priori* and without experiments to determine the nature and properties of bodies.

Thus Lead and Tin may be mixed together in ſuch proportions, as that the whole ſhall melt more eaſily than even Tin itſelf[b]. A compound of 3 parts Tin and 2 of Lead Sir *Iſaac* found to melt at his *gr.* 57, or our *gr.* $(\frac{57 \times 180}{34} + 32 =) 334$[c]. But if the Lead be in a greater proportion to the Tin a higher heat than that of melting Tin is requiſite to make the compound flow. For he experienced a heat of *gr.* 460 to be required to melt a mixture of 4 parts Lead and 1 part Tin[d]. When the Lead was to

[a] Mem. Ac. Sc. 1703. p. 247.
[b] Muſſchenbr. Ibid. Boerh. Chem. I. p. 751.
[c] Phil. Tranſ. Abr. IV, 2. p. 2. [d] Ibid.

the

ESSAY VI.

the Tin as 5 to 1, that heat was not able to keep the mixture in fusion [a].

What still vastly increases the fusibleness of these Metals is the addition of Bismuth or Tin-glass, a Marcasite or Sulphureo-metallic substance, not so easily melted as Tin. That Bismuth Sir *Isaac Newton* used in these curious experiments, we shall just now have occasion to copy from him, did not melt with a heat under *gr.* 460 [b]. And Dr. *Musschenbroek*'s Bismuth was much harder to dissolve, to wit at *gr.* 1051 [c]. And a golden Marcasite, though more fluxil, took *gr.* 506 to melt it.

A mixture of Tin and Tin-glass melts at a heat less than what is requisite to melt either separately [d]. When they were in equal quantities the compound melted at *gr.* 283 [e]. If you alter this proportion the mixture becomes susceptible of a greater heat. When the Tin was double the Bismuth it did not melt with a heat under *gr.* 334 [f]. And it stiffened in this heat when the Tin was to the Bismuth as 5 to 3 [g]. And if the proportion of Bismuth be very small, the heat required to keep the

[a] Ibid. [b] Ibid. [c] Musschenbr. Ibid. [d] Ibid.
[e] Newton. Ibid. p. 2. [f] Ibid. [g] Ibid.

compound in fuſion is ſtill greater, and comes nearer to that of melting Tin. When there was 8 times more Tin than Biſmuth in the mixture it would not melt with a heat under *gr.* 392[a].

We were told by Sir *Iſaac* that the heat of melting Lead was *gr.* 540, and that of Biſmuth 460. But theſe two bodies ſo difficult to be melted by themſelves, when blended together into one maſs, are much eaſier brought into fuſion. A mixture of them in equal quantities but juſt ſtiffened at *gr.* 334[b]; and ſo would melt with very little more heat.

But what is moſt ſurpriſing of all is the great fuſibleneſs of a mixture of all theſe three ingredients. Mr. *Homberg*[c] propoſed for an anatomical injection a compound Metal of Lead, Tin, and Biſmuth in equal parts, which he tells us keeps in fuſion with a heat ſo moderate that it would not ſinge paper. Sir *Iſaac* contrived a mixture of them in ſuch proportions that it melted and kept fluid with a heat ſtill ſmaller, not very much exceeding that of boiling water. A compound of 2 parts Lead, 3 parts Tin,

[a] Ibid. [b] Idem, Ibid. [c] Mem. Ac. Sc. 1699. p. 235.

and

ESSAY VI. and 5 of Bismuth but just stiffened at that very heat [a]. And so would have fluxed with very little more. And another mixture of the same materials in a proportion somewhat different from that actually melted by the heat of *gr.* 246 [b]. It consisted of the Lead, Tin, and Bismuth in the proportions to one another of 1, 4 and 5.

Antimony is a mineral compounded of sulphureous and metallic parts. The metallic substance, when separated from the other, is called its *Regulus*. This is able to bear a great heat without melting. When prepared with Iron, and so going under the name of *Regulus Martis*, it was found to stiffen only at *gr.* 805 [c], and so would take a heat something greater thoroughly to melt it.

But this Regulus fluxes something easier when mixed with Tin or Bismuth. A mixture of it and Tin in equal portions was found to melt at *gr.* 635 [d]. When the Regulus exceeded 5 times the quantity of Tin it stiffened at *gr.* 752 [e]. And so too did a mixture of Regulus and Bismuth in the proportions of 2 to 1 [f]. But when

[a] Newton, Ibid. [b] Idem, ibid. [c] Idem, Ibid. p. 3.
[d] Idem, ibid. [e] Idem, Ibid. [f] Idem, Ibid.

the Regulus was in lower proportion to the Bismuth, as in the ratio of 4 to 7, the compound was easier melted; for it stiffened at *gr.* 635 [a].

Though it would seem by these experiments that the Metal of Antimony gave the Tin and Tin-glass a power of resisting the fire, and that even something greater than its proportional quantity in the mixtures should require; yet it promotes the fluxibility of the harder Metals. When added to red hot Iron it soon brings it into fusion [b]. And it increases the fusibleness and volatility of some of the other Metals [c].

☾. ☉. ♀. ♂.

The *Hard Metals*, Silver, Gold, Copper and Iron require a more intense degree of heat to destroy their consistency, and bring them into a fluid state. And before that too they undergo a very remarkable change, appearing in a shining form; when we know that they have a vast burning force, far exceeding the heat of ordinary hot bodies, as the summer air, boiling water, &c. the pro-

[a] Id. Ibid. [b] Boerh. Chem. I. p. 55. II. p. 511.
[c] Ibid. I. p. 34. 38.

portions

ESSAY VI. portions of which ſome have endeavoured to determine.

Dr. *Keill* [a] affirms "the heat of red hot "Iron to be only 7 times greater than the "ordinary heat of the ſun in ſummer." But this ordinary heat of the ſun in ſummer is not a very definite thing, eſpecially as then underſtood. So that we are not quite ſure what Dr. *Keill* really reckoned to be the heat of red hot Iron. Though I ſuppoſe he had ſome view to what he found in Sir *Iſaac Newton* on that ſubject.

Very early had this great man been making experiments on the various degrees of heat in bodies. And it was from theſe his firſt trials he had what he ſays of them in his *Principia*, reckoning the heat of red hot Iron to be 3 or 4 times greater than that of boiling water [b]: almoſt as Dr. *Pitcairn* ſoon after gave out the matter in his colleges at *Leyden* [c], to whom I am ready to think Sir *Iſaac* had communicated this obſervation, that "by the heat of our ſum-"mer air the Oil is raiſed in the Ther-"mometer 7 ½ degrees, by the heat of our "ſkin to *gr.* 17; by boiling water to *gr.* "50 or 52; by the heat of red hot Iron

[a] Exam. of Burn. Theor. p. 156.
[b] Princip. p. 508. [c] Elem. Med. II, 1. §. 26.

"to

" to thrice that number," or to *gr.* (180×3+32=)572 in our ſcale.

But upon what grounds Sir *Iſaac* reckoned red hot Iron (*ferrum candens*) to be but 3 or 4 times hotter than boiling water I cannot well tell. Nor how either he or Dr. *Pitcairn* could determine the dilatation of Linſeed Oil by the direct application of the heat of red hot Iron, can I conceive any way poſſible; for it boils by a much leſs heat than that. And if you were to imagine Oil to expand regularly as far as you pleaſe without boiling, the heat of red hot Iron would carry it much beyond 150 or 200 ſuch degrees; that is to ſay it would dilate the Oil much more than 3 or 4 times the expanſion given it by boiling water.

It is true Sir *Iſaac* gives out this computation only as a conjecture; which however as it ſtands in the firſt edition is ſtill preſerved without the leaſt alteration in both the other two: though he had long before he publiſhed them made ſome new experiments, whereby in a very ingenious way he had found the heat of red hot Iron to be a good deal higher. For his firſt enquiries concerning the comparative heat of bodies muſt (as is commonly the fate of all firſt

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eſſays) have laboured under ſome imperfection. But as this affair was well worth proſecuting, his great and inquiſitive genius did not reſt in them. He repeated his trials with greater care and exactneſs; and *an.* 1701 gave in to the Royal Society the reſult of them in that excellent paper (to which already we have been ſo much beholden for ſo many curious experiments and uſeful hints) containing *a ſcale of the degrees of heat* determined with an Oil Thermometer and a lump of red hot Iron [a].

Of this method of determining the degrees of heat we have already [b] had occaſion to ſpeak more fully. It is the reſult of his obſervations we are juſt now concerned with. And we are told [c] that at his *gr.* 114, which coincides with our *gr.* $(\frac{114 \times 180}{34} + 32 =) 635$ heated bodies begin to ſhine in the dark, but juſt ſo as to be perceptible. This may be called the *ſhining point of Heat*. But I would ſuppoſe from the train of Sir *Iſaac*'s experiments, that this and what he ſays farther of the ſplendor of heated bodies is to be meant ſolely of Iron. For it is likely

[a] Phil. Tranſ. Abr. IV, 2. p. 1, &c.
[b] Eſſ. V. §. 3, &c. [c] Phil. Tranſ. Ibid. p. 3.

enough

enough that different Metals and other bodies may arrive at their ſhining heats in different degrees.

But Iron muſt be vaſtly heated beyond this to have the character of being red hot. Before it can ſhine briſkly even in the dark it muſt be at *gr.* 752 [a]. And yet then it has no perceptible ſplendor in the twilight. And it is not till the heat arrive at *gr.* 884 that bodies ſhine diſtinctly in the twilight immediately before ſun-riſing or after its ſetting [b]; but not at all or very obſcurely in ſtrong day-light. And agreeable hereto we find among Dr. *Muſſchenbroek*'s experiments [c] an Iron Rod heated, but not reddened in the fire to have been lengthened 276 degrees of his Pyrometer; which falls on *gr.* $(\frac{276}{53} \times \frac{180}{1} + 32 =) 969$ in our ſcale.

In Sir *Iſaac*'s reckoning the heat of a ſmall pit coal fire unblown and of Iron heated red hot in it was *gr.* $\frac{192}{34} \times \frac{180}{1} + 32 =) 1049$ [d]. And a rod of Steel heated in the fire till it was red, Dr. *Muſſchenbroek* [e] found to be lengthened 364 of his degrees; and conſequently to have been heated to our *gr.* $(\frac{364}{56} \times \frac{180}{1} + 32 =) 1095$:

[a] Ibid. [b] Ibid. [c] Tent. Exp. Ac. Cim. Add. II. p. 47. 48. [d] Phil. Tranſ. Ibid. [e] Tent. &c. Ibid. p. 48. 49.

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you see not differing much from Sir *Isaac*'s heat of a small pit coal fire.

But he [a] gives out the heat of a small wood fire as greater, amounting perhaps to his *gr.* 200 or 210; which is our *gr.* $(\frac{210}{34} \times \frac{180}{1} + 32 =) 1408$. And a greater fire he justly reckons hotter still, especially if blown with bellows. Copper shining hot from the fire *Musschenbroek* [b] found lengthened 392 divisions, that is to our *gr.* $(\frac{392}{59} \times \frac{180}{1} + 32 =) 1228$. And to be sure Iron in reddening and melting takes on a greater heat than Copper.

This matter to be farther prosecuted by experiments.

VIII. *Of the boiling Heats of Liquid and Melted Bodies.*

A very moderate degree of heat, no greater than that of hot animals, is sufficient to generate air bubbles in fresh *Water*. But to make it really boil a vastly greater heat is required. By the very construction of our Thermometers that happens when the Mercury is raised to *gr.* 212: beyond which Water is incapable of being heated

[a] Phil. Transf. Ibid. [b] Tent. &c. Ibid. p. 49, 50.

in

in an ordinary ſtate of the atmoſphere. Which circumſtance is to be underſtood too of the *Boiling Heats* of the other fluids we ſhall have occaſion to mention.

Sea Water in boiling does not take on a heat ſenſibly greater than common Water. But if the Water be as ſtrongly impregnated with Salt as it is capable of being, it is ſuſceptible of ſome more heat. Dr. *Boerhaave* [a] found ſuch a ſtrong pickle boil up to the heat of *gr.* 218.

A *Lixive of Pot Aſhes* is heated to *gr.* 240 before it boils [b]. And the common *Saline Spirits,* which are ſtrong ſolutions of volatiliſed acid Salts in water, bear this great or a greater degree of heat. Spirit of Nitre comes to *gr.* 242 [c]. And I ſuppoſe Aqua Fortis, Spirit of Salt, *&c.* are ſuſceptible of much the ſame. But Oil of Vitriol, that ſtrongeſt of all the Acid Spirits (and Oil of Sulphur *per Campanam* is much akin to it) goes to a vaſtly greater heat, to wit, to *gr.* 546 [d].

But the common true *Oils* require ſtill a much greater heat to bring them a boiling. It is true *Alcohol* boils with the loweſt de-

[a] Chem. I. p. 746. [b] Phil. Tranſ. Abr. VI, 2. p. 18. [c] Ibid. [d] Ibid.

gree

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gree of heat of any liquor, to wit at *gr.* 174 or 175 [a]; and Brandy at about *gr.* 190, as I have experienced. And Alcohol is but a thin Oil. But then by the proceſſes of Fermentation and Diſtillation it is ſo much ſubtiliſed and attenuated, as to become thinner, more volatile, and eaſier boiled than Water itſelf; as Lord *Verulam* too long ago obſerved [b].

Thoſe Oils that have any lentor in them have a much ſtronger coheſion of parts, and can bear a much greater heat. "Majorem calorem deſiderat ad hoc ut bul-"liat oleum, quam Aqua; & tardius "multo bullire incipit," ſays the ſame Lord *Verulam* [c]. Oil of Turpentine is amongſt the thinneſt of all theſe, and yet in boiling it raiſed the Mercury in the Thermometer almoſt to *gr.* 560 [d]. And hereabout I reckon the boiling heat of the other ordinary Volatile or Stillatitious Oils. Which however as the boiling continues is always augmenting; the more volatile parts flying away, and leaving the reſidue

[a] Ibid. and Boerh. Chem. I. p. 168. 745. 746. 749.
[b] Hiſt. Denſ. &c. p. 46.
[c] Ibid. [d] Boerh. Chem. I. p. 747.

thicker,

thicker, ſtronger, and ſuſceptible of greater heat [a]. ESSAY VI.

The *Expreſſed fixed Oils* can take on ſtill a greater heat. I find Mr. *Fahrenheit* and Dr. *Boerhaave* ſpeaking as if they and Quickſilver began to boil at much the ſame degree of heat, *viz.* about *gr.* 600 [b]. And in boiling they are ſuſceptible of ſtill a much greater heat than this before they burſt out into flame. Dr. *Muſſchenbroek* has furniſhed us with a method of judging of that heat independently of the common Thermometers, from the lengthening of Metals expanded in it; by which the heat of boiling Oil came out conſiderably higher than what is aſſigned to Mercury boiling. From the freezing point he found [c] the elongation of an Iron Rod in Rapeſeed Oil ſo boiling as to be ready to burſt into flame to its elongation in boiling water as 201 to 53; and conſequently as 682 to 180. So that if the Mercurial Thermometer had been capable of being lengthened out far

[a] Ibid. and p. 748. and Phil. Tranſ. Ibid.

[b] Fahr. in Phil. Tranſ. Ibid. p. 18. 52. Boerh. Ibid. p. 165. 265. 291. 747. 748. 752. Muſſchenbr. Eſſ. Phyſ. §. 880. 952. 896.

[c] Tent. Exp. Ac. Cim. Add. II. p. 20.

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enough this Boiling Oil would have raised the Mercury in it to *gr.* 682+32=714; and that is a heat in the ordinary way of reckoning from above the freezing point, ($\frac{682}{180}=3\frac{4}{5}$) near 4 times greater than that of Boiling Water.

It is true a much lower heat made a sort of boiling noise and froth in the Oil, arising from the expulsion of its more watery parts. This came on when the Iron Rod was lengthened but 120 parts, and that lights about *gr.* 440 in our Thermometer. But this is but an accidental and indefinite sort of heat, and not at all to be reckoned the complete Boiling state of the Oil, or the greatest heat it is capable of without burning.

FINIS.

ERRATA.

PAG. 10. lin. 2. read *and be.* p. 49, 17. r. *Pleurisy.* p. 166, marg. l. 4. r. *Cheyne.* p. 167. marg. l. 2. r. *Extemp.* p. 178, 11. r. *measurers.* p. 185, 9. r. *bypast.* p. 189, 15. after parts add a ,. p. 228, 11. r. XII. p. 229, 10. r. XIII. p. 298, 23. for 60. r. 70. p. 299, 8. r. *those.* p. 342. marg. l. 5. for *the greatest* r. *a great.* Ibid. l. 7. for *healthy and natural* r. *natural healthy.* p. 357. for *must too* r. *too must.* p. 349, 14. r. *those.* p. 353. marg. r. *De Reaumur.* p. 354. for , r. ;.